THE ENGINEERING RECORD

Published Weekly by the

McGraw Publishing Company

MAIN OFFICES:
114 Liberty Street, New York.
BRANCH OFFICES:
Philadelphia: Real Estate Trust Bldg.
Chicago: 1140 Monadnock Block.
Cleveland: Cuyahoga Building.
London Office: Hastings House, Norfolk St., Strand.

SUBSCRIPTION RATES.

United States, Canada, Cuba and Mexico...$3.00 a year.
Foreign subscription ....$6.00 a year.
25 shillings. 25 marks 31 francs.
Foreign subscriptions may be sent to our London office.

NOTICE TO ADVERTISERS.

Changes in advertisements intended for a particular issue should reach the office of The Engineering Record on Friday of the previous week. New advertisements can be received up to noon of Wednesday of the week of issue.

NOTICE TO SUBSCRIBERS.

Remittances.—Remittances should be made by check, New York draft, or money order, in favor of The Engineering Record.

Changes of Address.—The old address should be given as well as the new, and notice should be received a week in advance of the desired change.

Back Copies.—No copies of issues prior to September, 1904, are kept on sale, except in bound volumes.

Date on Wrapper indicates the month at the end of which subscription expires. The sending of remittances for renewal prior to that date will be much appreciated by the publishers.

Club Rate.—In acknowledgment of assistance rendered by subscribers in the securing of new orders, a club rate of $2.50 per annum is quoted. This rate applies to subscriptions in clubs of two or more, at least half of the names in the club to be those of new subscribers.

Entered at the New York Post-Office as Second Class mail matter.

Copyright, 1906, by the McGraw Publishing Co.

Of this issue of THE ENGINEERING RECORD 15,000 copies are printed. Total circulation for 1906 to date 566,250 copies. an average of 12,869 copies per week.

TABLE OF LEADING ARTICLES.

Problems of Minor Transportation.............. 477
Power Transmission by High-Tension Direct Current 477
The Capacity of Reinforced Concrete for Long-Span Masonry Construction 478
A Good Example 478
Progress on the Erection of the Blackwell's Island Bridge (Illustrated)........................ 480
The Foundations of the Trinity Annex and Boreel Buildings, New York. (Illustrated)............... 482
The Lesley Cement Laboratory, University of Pennsylvania. (Illustrated) 486
Interesting Bridge Shop Work.................... 487
The Turbine Pump of the Montreal Water Works. (Illustrated) 488
The Great Water-Works Project of Los Angeles.. 488
Mechanical Equipment of the Carnegie Library Extension, Pittsburg, Pa.—III. (Illustrated)...... 489
The Remarkable Settlement of a Concrete Building in Tunis. (Illustrated)......................... 492
Tests of Other Woods Than Pine for Paving Purposes.. 493
The Sale of Electric Power. (Illustrated)........ 495
The Trust Company of America Building.—III. (Illustrated) 498
Adjustment of Bench Levels. (Illustrated)....... 501
Chemical Engineering in the Packing Plant...... 502
Book Notes 503
Good Building Contract Forms.................. 504
Tests of Clay Pipes............................ 504

Problems of Minor Transportation.

No country has worked out more thoroughly than our own the grand strategy, so to speak, of general transportation. With an enormous area to contend with, and a people industrially active to an almost unprecedented degree, transportation has been provided to an extent marvellous to contemplate and at a price on the whole wonderfully low over the longer distances. In fact, the "long haul" has perhaps been too much favored, so that the population, as a whole, has not gained as it should by the apparent magnitude of the transportation facilities. If one examines critically the items which go to make up the cost of a manufactured article, he will generally find that what one may call the secondary charges against it, *i. e.* those due to transportation and middlemen's profits on the component materials, are an abnormal proportion of the whole, and oftentimes the local transportation is a still larger proportion when the article comes from its point of distribution to the consumer. It does not profit the consumer much that the first thousand miles of carriage is cheap, if the last fifty miles is dear enough to more than make up for it, especially if his own products come under short haul conditions. One of the big industrial problems is to improve local transportation so as to cut down the charges which it imposes upon both buyer and seller. This is, too, mainly a technical problem, to be solved only by the keen application of sound engineering principles to local carriage. It involves not only the broad question of roadbeds and traction machinery, but the special one of light railways, far too much neglected in this country of ours.

Animal traction as such has little to commend it from the economic standpoint. Considered as a machine, the horse leaves much to be desired. His fuel cost is very high, and repairs and depreciation run to a considerable percentage of the capital invested. If continuous output is desired, the first cost, too, is relatively large, while in discontinuous service the fuel and maintenance charges are almost the same as at full load. If he could be replaced by a machine of anywhere nearly the same first cost, the only reason for retaining him would be a sentimental one. As a mechanical proposition the automobile has altogether the best of the argument. The horse has only low first cost and large coefficient of adhesion to the good, *i. e.* he is, where small power is considered, cheap and he can work after a fashion on intolerably bad roads or on no roads at all. In a rural community the larger amount of transportation is not along railway lines, but to and from them, and the prosperity of the small town lies not in cheap freight rates between Chicago and Pittsburg, but in easy access to the county seat or the nearest railway junction, where competitive rates can be had. Mechanical haulage for such work is a very important consideration. Its success depends, first, on improvements in roads, to adapt them for motors, and, second, in cheapening the motors themselves. At the present moment one instinctively smiles at the idea of the agriculturalist taking his potatoes to market and his family to the county fair in a motor-car, but the contingency is not so remote as it might seem. At least one automobile manufacturer is making a deliberate drive at rural business, and if one asks, "Where are the cars of yesterday?" he may find not a few of them doing good service in small towns in the country districts. There is a very large amount of rural and suburban carriage that could be handled by motor cars to very great advantage, and the change is already beginning. It will not be long before the enterprising contractor will add a few motor cars to his equipment of teams, almost as a matter of course. To-day he is more than likely to be using the machine for running about and looking after his various work, and to-morrow he will be using it for transporting his material on a large scale. Of course, the motor truck is now a familiar sight in many cities.

The trouble is mainly the large first cost, due to the expense of development and the enormous sales charges, features incident to the growth of many new industries. Stripped of these the selling price of motor cars and motor trucks will soon settle to a very business-like basis, when the large industrial use will promptly begin. Meanwhile it behooves the community to prepare for the new situation by looking after the grades and surfaces of its highways. This is not a thing to be done for the benefit of a few wealthy automobilists who scorch, but for the people at large. The sooner the average road is made practicable for motor vehicles without undue wear on the tires, the sooner will motor traction come to the rescue of the smaller communities. The need of enormous resilience in the tires, owing to bad roads, is to-day the most troublesome feature of automobile construction, and the chief item of maintenance. It is perfectly possible to produce at the present time a reliable and durable chassis, with an engine of power adequate for light traction purposes, at a surprisingly low figure, when building in quantity. The necessary maintenance and depreciation charges will be governed mainly by the character of the roads provided. There is constant growling over the magnitude of these items, but when one considers the fact that he is driving a heavy vehicle at three or four times the speeds contemplated in the design of the roadbed, it is small wonder that repairs count up. For practical purposes roads should be well enough built to render the use of elaborate pneumatic tires quite needless for business vehicles or for anything but high speeds. Motor trucks and the like can cover ample ground at modest speeds and for their proper work should be designed for such. With suitable roads they are bound to play a very important part in the daily life of the smaller communities and are capable of keeping down the cost of transporting commodities, when the traffic is too small and irregular to justify the construction of even a light railroad.

Power Transmission by High-Tension Direct Current.

In The Engineering Record of Aug. 6, 1904, there was printed an account of some experiments made at Sécheron to determine the practicability of distributing power by a 70,000-volt, direct-current line. The apparatus employed was that designed by M. Réné Thury, chief engineer of the Compagnie de l'Industrie Electrique et Mecanique, of Geneva, who alone among eminent electrical engineers has refused to give way at all to the advantages of alternating current. He is probably best known to American civil engineers as a member of the technical committee which selected the equipment for the first plant of the Niagara Falls Power Co., and it seemed at one time that his influence would result in a direct-current installation at that station. This choice was not made, however, and he returned to Geneva, where he has continued to employ direct current under voltages which are surprisingly high to those who have not followed his work. During the last two years, particularly since the practicability of generating power at the Victoria Falls on the Zambesi River came up for discussion, his system has been receiving considerable attention, and an indication of the present swing of the pedulum toward direct current transmission is the recent purchase of his British patents by a leading electrical manufacturing company.

It must be confessed that two years ago this journal had little expectation of ever seeing any practical application of the results of the tests which it described at that time. About 25,000 volts was the highest tension then used on any of M. Thury's transmission lines, and the experiments with insulators carrying lines with a 70,000-volt current did not seem conclusive. Yet the "Electrical World" recently contained a description of the latest Thury installation in which not only can a pressure of 60,000 volts be maintained apparently without difficulty, but the power is transmitted a distance of nearly 115 miles. This installation is thus not only to be ranked among those of great length, but must also be accorded special significance on account of its character. It is surprisingly simple for a direct-current equipment, or for any type for that matter, and its satisfactory operation is something on which its designer is to be congratulated, particularly when it is considered that all features of it have been worked out in the face of the strongest sort of competition from the advocates of alternating current. In fact one of its most striking features is that the direct-current system connects up with several three-phase systems for a mutual exchange of energy.

The current is generated at a hydro-electric station at Moutiers, where there are sixteen constant-current dynamos connected in series, each with a capacity of 75 amperes and capable of being worked up to 3,900 volts. These dynamos are arranged in four groups, each driven by a turbine, but each group is separated into two pairs by an insulating coupling. Each pair of generators has a common bedplate which is insulated from the floor, and the latter is insulated. The whole power of the station is about 4,500 kw. at a maximum pressure of 60,000 volts. Each wheel when started is regulated by hand until it takes its share of the load, and a governor regulates all the wheels that are thus placed in operation. While the units are small and their connections seem complicated at first sight, this is probably not the case so far as the actual management of the apparatus is concerned. The insulation of the line, which seemed such a difficult thing to most observers, has been accomplished by three-part porcelain insulators of about the same size that would be employed on an American alternating-current system working at 35,000 volts. It is hardly necessary in this place to go into the novel details of the transmission line to Lyons, where the current is used, as these are features of the subject which concern more directly the electrical specialist. The important fact is that M. Thury has actually built and placed in operation a long distance transmission line using direct current at a voltage which even the advocates of alternating current regard as very high.

The Capacity of Reinforced Concrete for Long-Span Masonry Construction.

The evolution of reinforced concrete construction has already passed through two or three stages without yet having exhausted the adaptability of this composite material for many important purposes. Like every new combination of merit, it has been much overworked by its advocates in some directions, as well as having had its value underestimated by those whose faith in it has been shaken by ill-considered design and worse fabrication. As has already been indicated a number of times in these columns, reinforced concrete requires just as scrupulous care in its fabrication and use as structural steel, and the designs in which it is to be employed require the most thoughtful consideration and the highest type of engineering skill.

There are certain lines of construction which involve design and treatment for what may be termed long-span work. The prominent characteristic of ordinary stone or concrete masonry is massiveness, or such an arrangement of proportions and dimensions as to secure the performance of structural duty by virtue of weight or compressive resistance. This means the reverse of those characteristics which are exhibited by structural steel or other materials having a considerable or high capacity for resistance to tensile stresses. The general principles of treatment of the two classes of design are radically different. When concrete is reinforced by steel, parts of the combination acquire high capacity of resistance to tensile stresses, and its treatment in design must be correspondingly modified. While reinforced concrete beams or girders, for instance, cannot be used for the same length of span as those of rolled steel or those built up of plates and shapes, the treatment in design of the reinforced concrete is, strictly speaking, of the long-span kind.

Again, reinforced concrete struts or columns no longer possess the massive proportions of those of stone or plain concrete. Some late reinforced concrete columns exhibit the more slender proportions of a material possessing a comparatively high tensile capacity. This is particularly true of that class of columns in which the steel bands the concrete and at the same time possesses capacity for carrying high loads as a steel column, in contradistinction to that armored concrete in which are embedded small longitudinal rods not self-supporting but requiring heavy wiring of the columns to prevent the disrupting effect of the rods under compression from splitting them lengthwise.

Unquestionably a most useful extension of development of reinforced concrete lies in making such a combination as to develop its capacity for long-span applications. The economy of concrete as masonry will give to reinforced concrete a rapidly extending field, which, indeed, it has already partly occupied; but more than this is needed. No development of reinforced concrete construction can be considered fully satisfactory which does not give the steel reinforcement the most complete opportunity to impart to the composite result the maximum benefit of its presence. In the most effective design the steel must be so placed as to counteract or reduce to the greatest possible extent the lateral strains of the concrete. The comparatively low modulus of elasticity of the latter makes these lateral strains correspondingly large, and this affords to the steel reinforcement acting as an envelope just the desired condition necessary for the best effects. The reduction of the lateral strains of the concrete by the steel envelope correspondingly enhances its compressive resistance and makes proper a higher ratio between the unit stresses of the steel and concrete. It appears conservative to state that under these circumstances the working unit compression of the steel may be taken at least fifteen times that of the concrete, even if it be admitted that the ordinary ratio between the moduli of elasticity of the two materials is but twelve. There is here a point of most important consideration in the design of concrete-steel members or structures to carry high loads. A unit load as high as 750 lb. per square inch upon concrete in such a steel envelope may certainly be employed, and it would not be at all surprising if full-size tests should show that even higher working intensities are permissible.

In this long-span combination of concrete and steel it is imperative that the steel should be used in self-sustaining shape so that even under compression it can have no disrupting tendency on the concrete. On the contrary its disposition should be such as not only to envelop the concrete and support it laterally, but also to form an effective design of a steel column in itself. Although much has been done in developing concrete-steel construction, it is safe to say that its most efficient evolution in the future will lie in the direction of making such a combination as to justify the use of high working intensities in the concrete, while affording an opportunity to use the steel at its ordinary working intensities in the best column design as an independent material.

These observations are equally applicable to the three classes of structures or structural members to which concrete-steel is so admirably adapted—beams, columns and arches. The use of this material up to the present time has been limited mainly to those applications for which it was plainly suited, but its adoption in long-span work may be expected soon.

A Good Example.

The Lesley cement laboratory in the new engineering building of the University of Pennsylvania is something which many industrial leaders will find of much interest. This is not because they probably care very much about cement or the apparatus employed in testing it, but because this particular laboratory is one of the few evidences in this country of an appreciation by a manufacturer of what he owes to the particular industry in which he has achieved distinction and by which he has gained wealth. It is a matter of common knowledge that nobody can continue to wring profit from a calling unceasingly without giving something back. If somebody is not educated so as to share the burdens of a business, then it ceases to develop. Formerly the only place to get this special education was in the works and shops; but now the technical colleges lay the foundations for acquiring such information so well and so thoroughly that the great industrial leaders of the future will inevitably be recruited from among the ranks of their graduates. This fact was recognized by the donor of the laboratory described elsewhere in this issue, and he accordingly told the authorities of the unversity where he was once a student to furnish at his expense all the equipment needed to enable its students to acquire a knowledge of the products which he had been making for many years.

This gift is one that can be emulated by hundreds of men with great advantage to their successors in the management of large industries. There is hardly a technical college in the country which is not in need of new equipment in order that the instruction given to the students may be of the highest usefulness. These special laboratories and shops and endowments will probably do more than any other one thing, not only to recall the careers of their donors, but also to prepare young men to follow in their footsteps. It is idle to say that these great manufacturing establishments can be continued successfully by the old methods of drafting men without education from the works into the business offices. There will always be a few men whose natural abilities will enable them to rise above the narrow limitations of their early days, but their number is very few. Manufacturing establishments are now so large that the workmen no longer have the opportunity that formerly existed in the days of small shops to become acquainted with all departments. The tendency among workmen now seems to be to drift where the wages are the highest without regard to future opportunities. With the young man of technical education this is not the case. His undergraduate studies have shown him the field which is most to his taste and have given him the mental equipment to recognize its relations with other fields. The better his education the more thorough is his grasp of the relations of things, which is something every successful man must know. He is accordingly able to go into an industrial establishment with a mental equipment which puts him far ahead of those who have not been to a technical college. He may not be such a good mechanic, but he is a far better director of the work of mechanics. He may not know at first so much about the little details that go to make up success in an industrial process, but he will easily learn them and then better them, as is well shown in an article elsewhere in this issue on chemical engineering in the packing industry.

In suggesting that more of these laboratories might be well given to our technical colleges by men who have achieved high positions in American manufacturing circles, there is another important fact to be considered. There are a good many industries now approaching such size that in periods of business depression it will be very desirable to have foreign markets for surplus products. The country is so great and its population has been growing so fast that its capacity for absorbing manufactured products has seemed almost limitless. It has an end, however, and that end has been pretty nearly reached in some lines already. The time is coming very soon when the American manufacturer will be forced to make a strong bid for the trade of the world, and when that time comes it is absolutely essential for him to be an educated man of broad views. The technical colleges of the country are now busily engaged in turning out these men, and they deserve a great deal more assistance from our industrial leaders than they are getting, just on this account. In the past, the schools have been narrow and have been content to teach technical subjects. It is true that they have taught a smattering of a few languages and a little English literature or the like, but these subjects have received no recognition from most of the teachers, and, consequently, have very naturally been looked upon by the students as of little account. It is only recently that the trustees of these schools have awakened to the importance of making their courses of a broad character, by insisting that the recitations in every class shall be so conducted that the students are compelled to express themselves as clearly and concisely as they can, by raising the study of foreign languages to a position of dignity and by requiring the teachers to impress upon the students the necessity of business-like conduct of all things, little as well as great, and the value of general culture. Instead of inclining their students to envelop themselves in a shell of scientific learning, these technical colleges are now teaching the opposite, and every year sees a broadening of the vision of the graduating classes as well as an improvement in their technical attainments.

This improvement must be greater, however, for the country greatly needs men of technical ability who are able to be leaders of public opinion as well as of industrial progress. We must look for these men to the technical schools, and these schools should be helped by the men who have become rich through industrial enterprises. These schools not only need laboratories, but they also need great endowments, so as to be able to attract to their teaching forces men of the first rank. This does not mean that men of the highest professional reputation are not now engaged in teaching, but rather that these men must have better assistants, and the whole salary list must be so raised that a technical college can compete with a railroad or manufacturing company to secure the services of some specialist who is needed to round out its corps of teachers. Anybody who has had an opportunity to go behind the outposts of a great German manufacturing corporation does not need to be told what an advantage it possesses in its great staff of splendidly educated men in all places of responsibility, and it does not need the gift of prophecy to see that the continued progress of our own industries will depend largely on the development here of a similar body of technical men of broad education. Our young men are able and willing to receive this education, and for this reason the technical schools, which can give it best, should receive every possible help.

Notes and Comments.

THE SIMPLON TUNNEL is causing its engineers some perplexity on account of the distortion of the roof of the second tunnel, driven parallel to the first in order to facilitate the work. The official report on this occurrence reads: "Lately the roof of the second tunnel, owing to the great pressure, has partly fallen in, necessitating the immediate undertaking of the work of repairing the vault of the tunnel."

THE RECLAMATION OF THE ZUIDER ZEE has been under discussion for so many years that little attention will probably be drawn to anything now printed on the subject. Nevertheless engineers ought to be interested in the fact that the Netherlands legislature has approved a government project for this work. At the present time the area of the Netherlands is about 12,700 square miles, and that of the Zuider Zee about 2,000 square miles. Originally the lake was much smaller and the government's project contemplates its reduction to about 460 square miles. The main feature of the work is to be a dike about 20 miles long and 30 ft. thick at an elevation of 18 ft. above the sea. It is estimated that about eight years will be required to construct this dike, and during this time a system of canals for the reclamation of the enclosed land can also be undertaken. The cost of the whole work is estimated to be about $60,000,000.

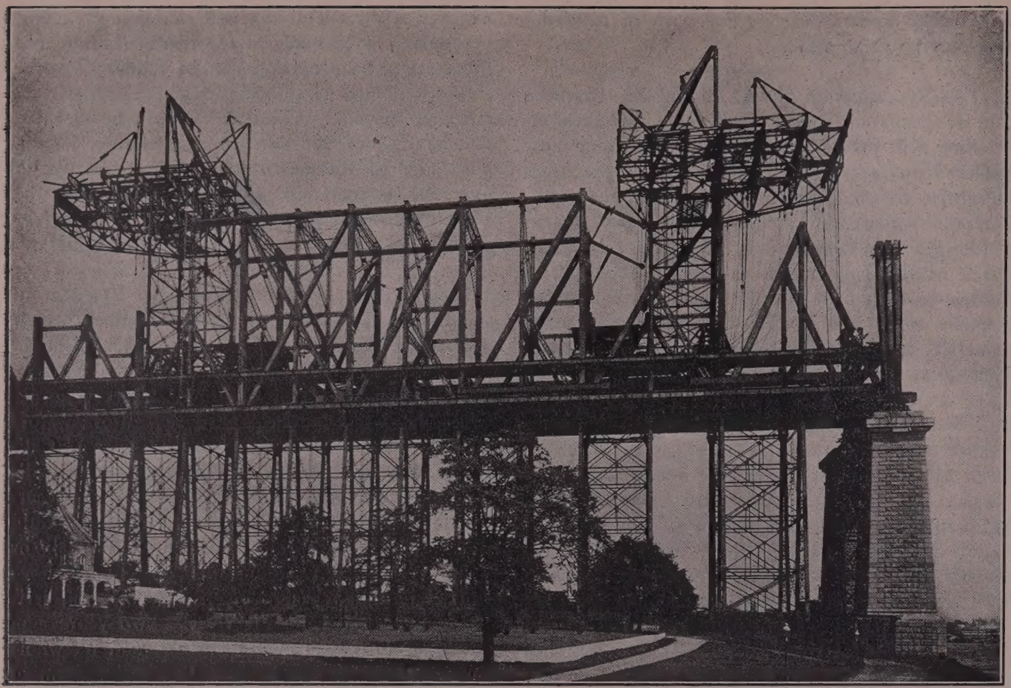
THE DEVELOPMENT OF KINKORA, N. J., the town built by the John A. Roebling's Sons Co., affords an example of the best type of an American industrial town. The growth of the company's business made it necessary to leave the restricted space at the Trenton works and seek a new site for a plant to produce the rods needed in making wire. Accordingly a large farm on the Delaware River was purchased, a steel mill, two rolling mills and a power plant have been erected, and a large town with nothing but neat brick buildings has been laid out and provided with water, sewerage and lighting facilities. Special attention has been paid to the design of the workmen's houses, so that every grade of accommodations likely to be required will be furnished, and all of them will be comfortable.

THE STEEL CORPORATION'S RELATIVE POSITION in the iron trade is shown by some statistics compiled by the American Iron and Steel Association. It furnished 56 per cent. of the shipments of Lake Superior ore in 1905, 43.4 per cent. of the total iron ore production, and 37.9 per cent. of the coke. It supplied 43.8 per cent. of all pig iron and 74.9 per cent. of the spiegeleisen, ferro-manganese, ferro-phosphorus and like materials. It produced 67.4 per cent. of the Bessemer steel ingots and castings, and 51.4 per cent. of the open-hearth steel ingots and castings, and 51.4 per cent. of the open-hearth steel ingots and castings. It made 47.3 per cent. of the rails, structural shapes, plates, rods and bars, 66.1 per cent. of the wire nails and 71.3 per cent. of tin and terne plates. The statistics, which will be found in detail in the "Bulletin" of the Association for Sept. 1, shows further that while the U. S. Steel Corporation made great progress during 1902-5 inclusive in enlarging and utilizing its productive capacity, the progress made by independent companies in the same period has been productive of a little larger aggregate tonnage increase.

THE NEW CHICAGO TERMINAL which the Chicago & Northwestern Ry. will build soon, is to embody the results of a study by President Hughitt and his staff lasting several years, and also present in its main details the results of an investigation made during the last year and a half by Mr. John F. Wallace, whose fitness for this work was thoroughly established by the fine showing of the Illinois Central combined suburban and World's Fair service in 1893. The present station can only be reached by a double-track drawbridge, and as any such structure is likely to cause delays in train movements, the new station will be located on Canal St., occupying three blocks between Madison and Lake Sts., and can be reached by trains without crossing the Chicago River. The site will enable a great improvement to be made in the tracks leading into the station, as provision can be made for three tracks for each of the two divisions of the road entering the city. These tracks will be elevated and have a new location for part of their length. The cost of the new terminal is estimated at over $15,000,000, and when it is completed the present terminal on the north side of the river will be devoted exclusively to freight business.

THE DIVERSION OF THE COLORADO RIVER from the Salton Sink back to its old channel, which was successfully accomplished on Oct. 23, marks the beginning of the end of a remarkable engineering episode. The Colorado desert is a depression in the southern part of California, formerly a portion of the bed of the Gulf of California, from which it is now separated by a sedimentary ridge built up by the river. This desert is considerably lower than the level of the Gulf. Its soil is very fertile, and within the last six or seven years many thousands of settlers have moved into this basin, which is now being irrigated by water from the river. Two years ago, the river broke through its banks and its whole volume began to pour into the basin, forming little by little in the Salton Sink a great lake. This has risen gradually, compelling the Southern Pacific Co. to shift its tracks a number of times and threatening to submerge eventually the land which was being developed so successfully. The railway company accordingly took steps to stop the break, the work being under the direction of Mr. H. T. Corey. The plan of partly closing the opening with a dam and then shutting it off entirely with wooden gates proved unsuccessful, for the gates were washed away. The closure has been finally accomplished by dumping into the breach enormous quantities of gravel and rock, brought to the site as rapidly as possible.

THE PENNSYLVANIA CAPITOL SCANDAL points out emphatically the necessity of careful supervision of public works. Here was a building erected by a special commission within the appropriation made for it, according to a statement made by a well-known member of the American Society of Civil Engineers, who was connected with the work in a consulting capacity in order that his wide experience in the construction of the highest class of public buildings might be utilized in securing good work at Harrisburg. His statement that the building was turned over to the State Board of Grounds and Buildings in a practically completed condition, except for the lighting fixtures and a few minor details, will be accepted by engineers and architects as true. The State Board, however, has already spent nearly nine millions of dollars in "furnishing" the structure, relying for authority to do so on a clause in a general bill granting the Board the right to spend money in the Treasurer's hands, otherwise not appropriated, for the purpose of furnishing and fitting out the structure. So the citizens have learned that instead of $4,500,000, the contract price for their capitol, its embellishment and furniture have raised the total cost to at least $13,500,000. It is difficult to reach any definite understanding of the real conditions of the matter because it is now a subject of political debate in which an impartial observer can readily discern evidences of juggling with the facts by most of those taking part in it. It should be pointed out, however, that the real seriousness of the matter is not the fact that some of the contractors may have supplied poor materials or done bad work, but that three men were given power to saddle the State with such enormous expense without any check upon them, and that these men were so negligent of their duty to the public as to fail to report at regular intervals the expenditures they were incurring.



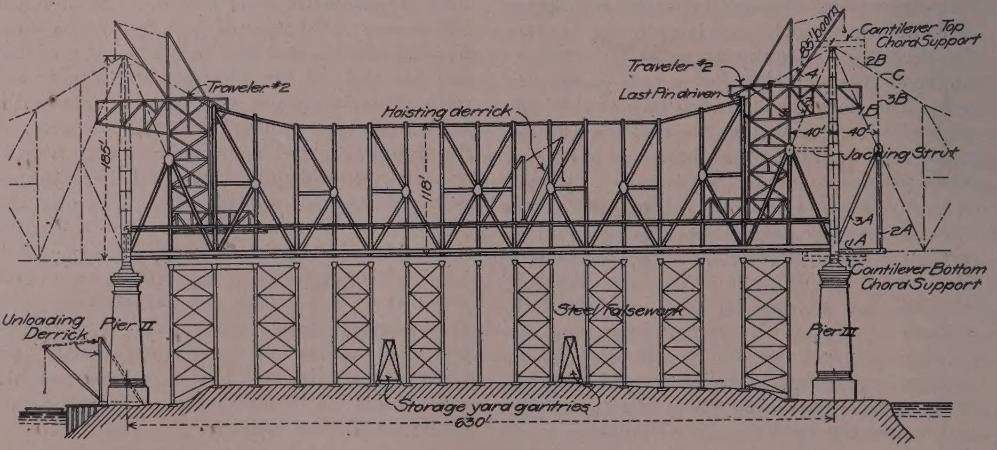
Traveler No. 2 Approaching Pier 3, Sept. 15.

PROGRESS ON THE ERECTION OF THE BLACKWELL'S ISLAND BRIDGE, NEW YORK.

A report, dated Oct. 20, 1906, of the resident engineer of the Blackwell's Island bridge, shows that of the total estimated weight of about 50,000 tons for the superstructure of the main spans, 44,747 tons of material have been shipped to the bridge shops, 17,365 tons have been received on the island, and 10,703 tons have been erected, 5,128 tons of the latter amount having been erected since the resumption of work in May. Since the completion of the two No. 2 Z-shaped, 500-ton travelers, 120 ft. high, the erection of the 630-ft., 12,000-ton island span has been nearly completed. The accompanying erection diagram is reproduced from the resident engineer's report of Oct. 20 and indicates the erected portions of the superstructure by heavy lines, and the part to be erected by broken lines. The steel falsework and traveler are indicated by light full lines. Since this report was made, the caps have been placed on the towers on pier 3.

The erection of the pier bents or towers, although not the most difficult or heaviest part of the span, is a slow and important operation on account of the great size and rigidity of the post sections and the fact that the last pins in the connections of the trusses are driven at the ends while the travelers are in the positions here indicated. The pier bents, 95 ft. wide at the bottom, 60 ft. at the top and 185 ft. high on centers, weigh about 2,650,000 lb. each, exclusive of the two 250,000-lb. cast-steel pedestals, and have, as described in The Engineering Record of May 20 and 27, 1905, two main inclined posts with theoretical cross-sectional areas of 1,250 sq. in., each made with a cap and nine sections of nearly equal length, erected separately. The posts are each battered transversely 17½ ft. in the total length and are in vertical planes, braced together with top and bottom portals, intermediate X-bracing and an additional transverse girder at the upper ends. In the plane transverse to the bridge axis the posts have a uniform width of 64 in. over all up to the bottom of the top section. Parallel with the bridge axis, they are tapered, the width varying from 7 ft. at the top and bottom to 11 ft. in the center. The post has a rectangular closed cross-section throughout, which is made with two interior webs transverse to the bridge axis. At the top and bottom these are reinforced by longitudinal and transverse diaphragms connected to the horizontal plates. All the post sections have milled butt joints spliced with inside and outside cover plates, all of which are service-bolted during erection, and will not be riveted until after the erection of the cantilever arms is well advanced.

The erection of the pier bents was commenced with the placing of the pedestals and pier girders, after which work on them was suspended until the island span had been virtually erected up to both piers, this sequence being permissible because the design provided for assembling the intermediate panels of the truss without regard to the main posts. When the No. 2 travelers arrived at the panels next piers 2 and 3 and the upper parts of the trusses were completed up to the second panels from the piers, the erection of the pier bents was commenced. The lower sections of the pier columns were seated on the pedestals and were secured there only by their anchor bolts, which had capacity considerably greater than was necessary to insure theoretical stability. The tops of the posts were, however, braced with timber struts to the floor-beams in the upper deck. The successive sections of the posts were assembled to the lower ones until the bent was erected to a sufficient height to receive the portal strut over the second floor and it was assembled in position, taking up the transverse reactions from the inclined posts. The towers were braced longitudinally by means of jacking struts located at about one half the height of the towers, and the erection of the bents was continued by assembling the successive sections of the posts and the lower panel of X-bracing above the bottom portal. The heaviest members of the posts weighed about 118,000 lb. each and were successively handled by the 65 ton feed derrick and the derrick located on top of the traveler.



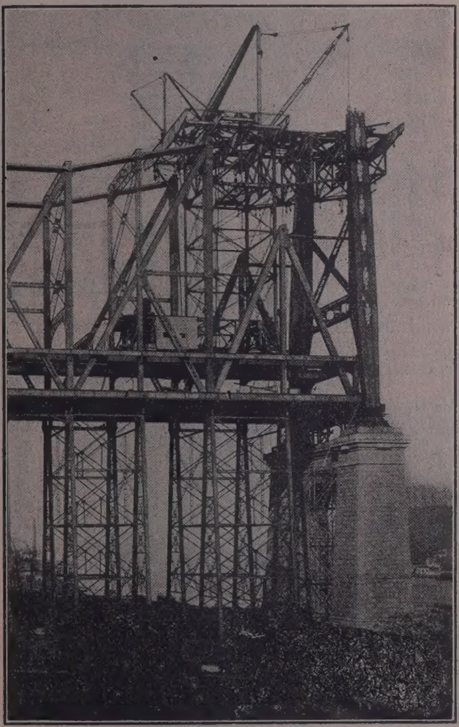
Positions of Travelers and Derricks on Oct. 20.

In order to provide for the top chord and diagonal connections, a special riveted cap weighing about 68 tons is seated on the upper section of each main post like a shoe or pedestal and is provided with two 14-in. pins for the connections to the inclined posts and two 16-in. pins above them for the top chord connections. These members are made with very massive webs corresponding with those in the special top sections of the posts, and are directly connected to a double-web latticed transverse girder 12 ft. deep.

While the first of these caps was being hoisted about 150 ft. from the ground to the top of the falsework, a 14-in. cast steel sheave breaking in the upper block of the 13-part 65-ton tackle rope caused the ⅞-in. wire rope led over it to break also, although the tackle had been tested by a much larger strain and had handled heavier loads without indications of distress. Fortunately the loose end of the broken rope became jammed in the upper block with the fragments of the sheave and prevented the tackle from overhauling, thus sustaining its heavy load at a height of about 125 ft. above the ground. The superintendent of erection immediately put several clamps on the lines in the upper part of the tackle so as to relieve greatly the stress in the upper block and quickly proceeded to erect two bents of timber falsework on the ground underneath the suspended cap, bracing them together to form a tower on which the cap was temporarily wedged to relieve the tackle of its weight. Meantime the rope which had been wound up during the hoisting of the piece was unwound from the engine drum, and the end of it being spliced to the broken part of the line gave a sufficient length to enable the tackle to be rove and the piece hoisted in safety to the falsework, where it was delivered to the service track on the cantilever brackets of the lower roadway transferred to pier No. 3 and finally erected in safety Oct. 23.

The No. 2 travelers, which are intended for the erection of the cantilever arms, have been built with enough clearance to pass between the vertical posts of the pier bents and underneath the upper portals of these bents. It is obvious, however, that when the travelers pass through these bents, the lower portal and the X-bracing between it and the upper portal must be removed,, leaving the bent temporarily braced only by the upper portal and the transverse girder above it. As soon as the travelers have passed through these bents, the lower portals and the X-bracing will be restored, and the travelers will continue outwards until they reach the ends of the cantilever arms, where they will be taken to pieces, lowered directly to barges in the river, transferred to the opposite shores and re-erected for the erection of the remainder of the superstructure. This avoids the necessity of retracing any part of their course over the finished structure in which the lateral bracing and sway bracing is permanently put in position behind them as fast as they advance, being handled by wooden boom derricks seated in the rear of the traveler, as indicated in the progress photographs.

As the dimensions of each traveler are limited to a height that will clear the portals of the pier bents, it is evident that the tackles suspended from the overhang cannot place the caps and upper members of the towers and tower panels. Provision is therefore made for erecting these and other members with the special 65-ton steel derricks having 85-ft. booms, described in the previous articles on this bridge. One of these derricks is seated, with its mast in the center of the forward bent of each traveler, and in this position has a radius sufficient to handle the upper part of the tower bent and all the members connected to it.

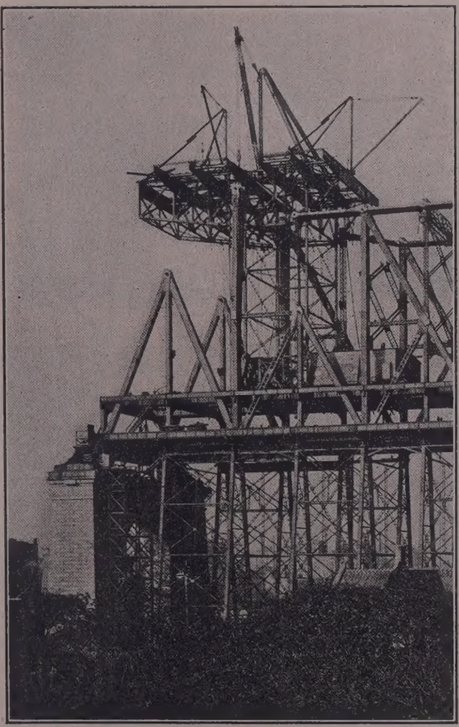


Traveler 2 at Pier 2, Oct. 5.

The operations planned for the completion of the channel span erection beyond the points reported on Oct. 20 are as follows, the different members being indicated on the diagram at pier 3, by figures showing the sequence of erection:

In each truss the cap, No. 1, will be erected, then the upper half, 2, of the diagonals will be erected, its upper end permanently connected to the cap and the lower end to the lower half of the diagonal. Then sub-post 3 will be erected and the lower end connected to the bottom of 2, then the end section, 4, of the chord panel will be erected and the upper end permanently connected to the cap. The lower end will be connected to the top of post 3 with a toggle pin, and finally this toggle pin will be removed and the permanent pin driven to connect it with the next top chord section, 5, which will be the last member erected. The pins at the lower ends of these eye-bars will then be driven, and the same operations at pier 2 will complete the truss.

In the erection of the top chord eye-bars it was at first intended to assemble half the bars for a single panel in their proper relative positions in the storage yard, where they were to be securely clamped, so that they could be hoisted and erected as a unit. This method was attempted, but, on account of the limited clearance at the top of the vertical post and the projecting angles there, it was impossible to drop the bars in from above, and they had to be inserted at an angle with the vertical, pushed several feet beyond the final position, and then pulled back to match the hole in the post. This operation was found difficult with a large number of bars closely packed, and in the erection of most of the panels the bars in the center group were clamped together and handled as a unit, and the remainder of the bars were assembled outside of them, separately or in two more groups. So far, all pins have been successfully driven by the ordinary method of the suspended ram.



Traveler 2 at Pier 3, Oct. 5.

On account of the reversal of camber in the channel span truss, due to the erection stress, the pier posts will be inclined from the vertical towards the center of the span about 7½ in. at pier 2, and about 3 in. at pier 3, when the island span is first connected up. These posts are erected in a vertical position, and to produce the inclination necessary for assembling the last panels of the span, provisions have been made to deflect them the required amount by horizontal forces which it is computed will not unduly stress the posts and will produce the flexure necessary to sufficiently displace the tops of the long members. For this purpose temporary erection members, called jacking struts, are provided, and connect the middle points of the tower posts with the adjacent intermediate truss pins, C58 and C74, at the center points of the main diagonal members 40 ft. distant horizontally from the centers of the tower posts.

Each jacking strut consists of two horizontal longitudinal telescopic members made of pairs of 15-in. channels latticed. One member is pin-connected to a horizontal diaphragm, bolted and thoroughly braced to the webs of the tower post. This member is nearly 40 ft. long and at the opposite end is engaged between the webs of a wider short strut, which at the other extremity is bolted to the connection plates of the diagonal post. The two struts are in the same horizontal line, and their overlapping ends are free to slide back and forth. Horizontal top and bottom flange plates at the end of each strut and a few feet distant from the end of each strut, carry vertical diaphragms between them which afford bearing on the center line of the strut for a single 70-ton hydraulic jack.

If the jack is placed between the end bearings of each strut, its operation will draw the struts together and produce a tension tending to pull the pier post toward the center of the span. If, however, the jack is placed between the other diaphragms, its operation will force the struts apart and bend the post in the opposite direction. Heavy horizontal screw rods are attached to the long strut and project beyond its end across the diaphragm in the short strut, which they engage with nuts on both sides. These nuts are always adjusted to take up any motion in either direction caused by the operation of the jacks, so that as fast as the vertical post is displaced the amount gained is held by the screws and will be secured if the jacks fail or are removed.

With this apparatus it is expected that the posts can be deflected sufficiently to make the eyebar connections and drive the last pins in the island truss, after which the positions of the posts will change automatically to correspond with the varying conditions of loading and erection. If, however, difficulty should arise in the operation of the jacking struts, the latter can be supplemented by tackles attached to the tops of the vertical posts which, with their increased leverage, will be able to produce any required deflection in the posts.

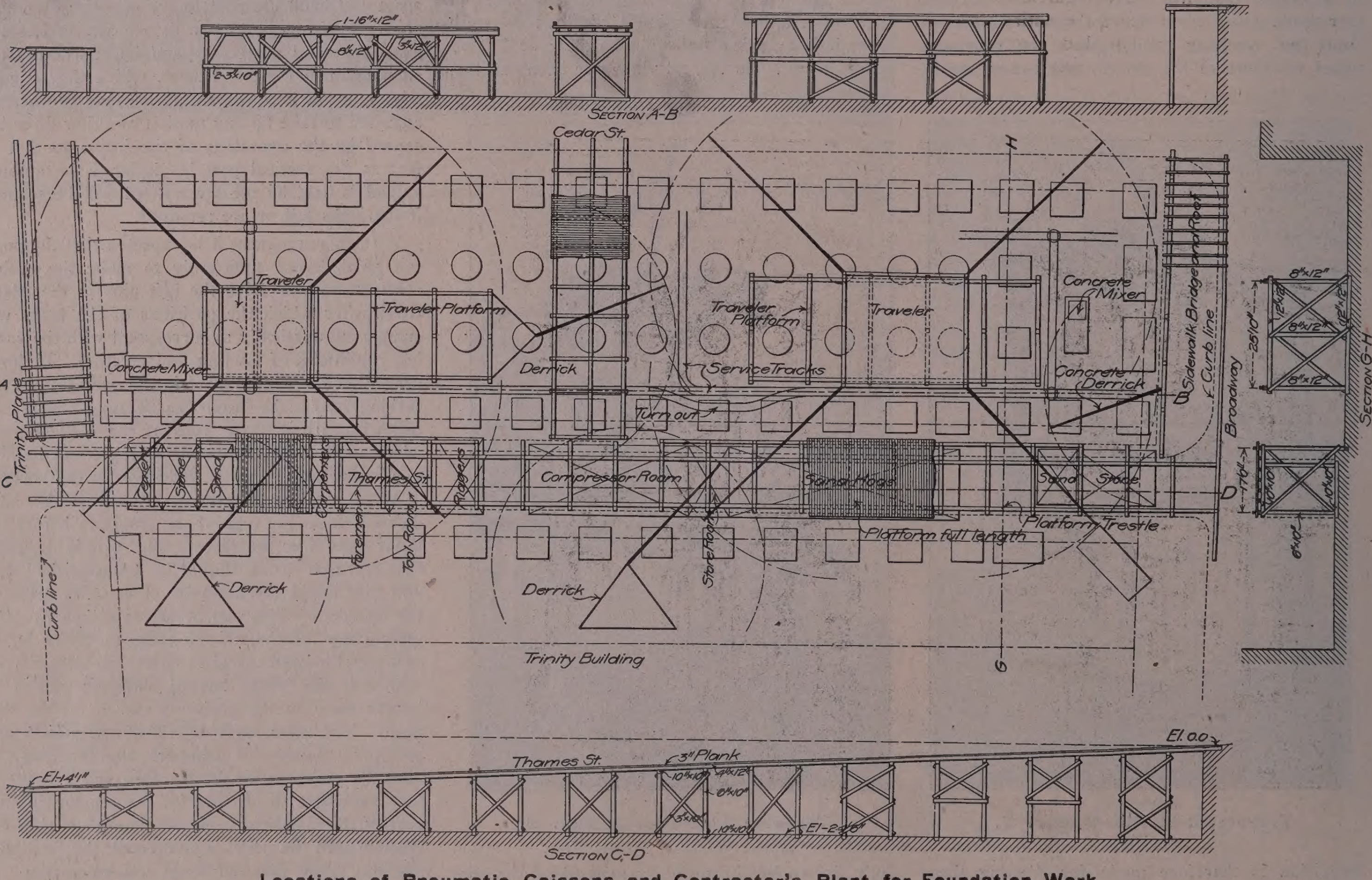
As it will be necessary to remove the steel derricks from the tops of the travelers before the latter pass over the piers 2 and 3, it is desirable that all their work should be accomplished first and thus avoid the necessity of erecting them on the travelers. This can be accomplished by completing the erection of the truss members in the first panel beyond the piers before the derricks are removed, the boom having sufficient radius to handle them in the positions shown on the diagram. The boom does not, however, afford support for a number of members simultaneously, as does the overhang of the traveler, and it is therefore necessary to provide for the temporary support of the members from the time when they are erected until the panel is completed, the final connections made, and the boom self-supporting.

This has been ingeniously accomplished, as shown on the diagram of pier 3, where a pair of regular floorbeams, each 60 ft. long and 10 ft. deep, were borrowed from the cantilever arms, hoisted to the top of the falsework, and temporarily placed transversely on the tops of the piers, as indicated by the light dotted lines. The floorbeams were placed 60 ft. apart in the planes of the truss, their forward ends overhanging about 34 ft. beyond the center of the pier. Reaction blocks were packed in at the opposite ends of the beams between their top flanges and the lower chord of the truss, so that they formed cantilevers loaded at the outer ends and fulcrumed on the piers. Blocking was placed on the overhangs to support the outer ends of the lower-chord sections of the first panels of the cantilever arms, which, in the sequence of their erection, are marked on the diagram 1*A*, and are permanently connected at the opposite ends. After these pieces were in position, the vertical posts 2*A* were erected, and the subdiagonals 3*A* were then erected by the derrick boom and their tops bolted to the top of posts 2*A*.

This work has already been accomplished at pier 3, and the remaining members in this panel will be erected in the sequence indicated by the reference numbers marked 1*B*, 2*B* and 3*B*. The upper end of the diagonal member 1*B* will be permanently connected to the top of the main post. The top chord 2*B* will then be erected and the upper end permanently connected. Its weight will be partly supported by suspension from a temporary cantilever provided by a floorbeam or stringer borrowed from the permanent structure and fulcrumed on top of the main post with its island and anchored to the top chord, as indicated by the diagram. All of these members having thus been hoisted to position, the derrick will be removed from the top of the traveler, and the latter will be advanced one panel. The top chord bars 2*B* will be blocked up from the top of the traveler to make the permanent connection at *C*, and the other members of the cantilever trusses can be readily handled by the regular tackles in the traveler. Similar operations will be made with the other traveler at pier 2.

The bridge was designed and is being erected under the direction of the Department of Bridges of New York City. The contractor for the manufacture and erection of the superstructure is the Pennsylvania Steel Company.

The McCall Ferry Power Development on the Susquehanna River in Lancaster County, Pa., has received an unexpected attack in the shape of a suit brought by the State Attorney General to obtain an injunction against the construction of a dam across the river. The action is based on alleged prospective damages due to the obstruction of navigation, interference with the Susquehanna Canal, the destruction of fishing grounds, and the flooding of riparian lands and valuable islands by backwater. The Attorney General asserts that the McCall Ferry Power Co. has acted and proposes to act far beyond its chartered rights.



Locations of Pneumatic Caissons and Contractor's Plant for Foundation Work.

The Foundations of the Trinity Annex and Boreel Buildings, New York.

Of the several very large office buildings now under construction in the financial district of New York, two of the first to be completed and together forming one of the largest and most costly undertakings will be the new Trinity and Boreel buildings on the west side of Broadway, just above Wall St., which together will occupy one entire block and part of an adjacent area nearly as great, and will represent a total investment of about $15,000,000. The sites were, until less than three years ago, occupied by the old five-story Trinity Building, with a 41-ft. 3-in. front on Broadway, and by the Boreel Building at the corner of Broadway and Cedar St., together with several other buildings of moderate height and old-fashioned construction which were used for general office purposes. The old Trinity Building had a depth of 260 ft. with one long side facing the open burial ground of Trinity Church. It was thus permanently assured against obstruction on this side, and its value was high on account of the exceptionally good light and air and pleasant surroundings in the most valuable locality in New York City.

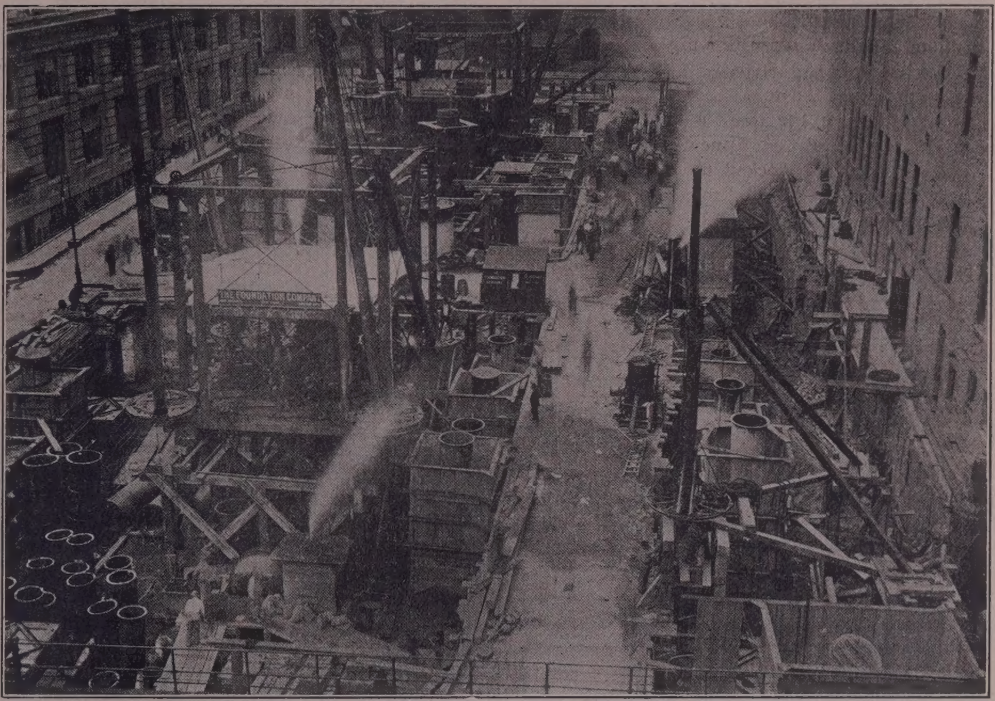
In 1904 the old Trinity Building was replaced by a twenty-one-story steel cage structure which occupies the whole of the 41x260-ft. lot, and was built on pneumatic caisson piers carried down to solid rock as described in The Engineering Record of Sept. 3, 1904. Foundations were completed May 20, 1904, and the superstructure was erected so rapidly that the steel framework was completed in October of that year, and the building was occupied by tenants early in 1905. The architect departed from the conventional design of office building exteriors and made the carved ashlar limestone in the exposed faces harmonize with the beautiful gothic architecture of the adjacent Trinity Church, from which it derives its name, the result being an admirable effect which has been much praised.

Subsequent to the completion of the Trinity Building, the remainder of the block adjacent to it on the north, from Thames St. to Cedar St., between Broadway and Trinity Pl., was acquired and arrangements were completed for covering the whole area with a structure practically duplicating the design of the new Trinity Building. This control of the entire property under the same ownership enabled the land to be more advantageously divided by an arrangement with the city of New York, permitting changes in the location of Thames St., which intersected the property from east to west, and justified the abolition of Temple St., a narrow lane extending only from Thames St. to Liberty St., midway between Broadway and Trinity Pl. An area equivalent to this lane was added to Thames St., increasing its width to 30¼ ft., and the street itself was moved about 27½ ft. north, parallel with its own axis, dividing the land between Trinity churchyard and Cedar St. more advantageously, and giving a better thoroughfare from Broadway to Trinity Pl.

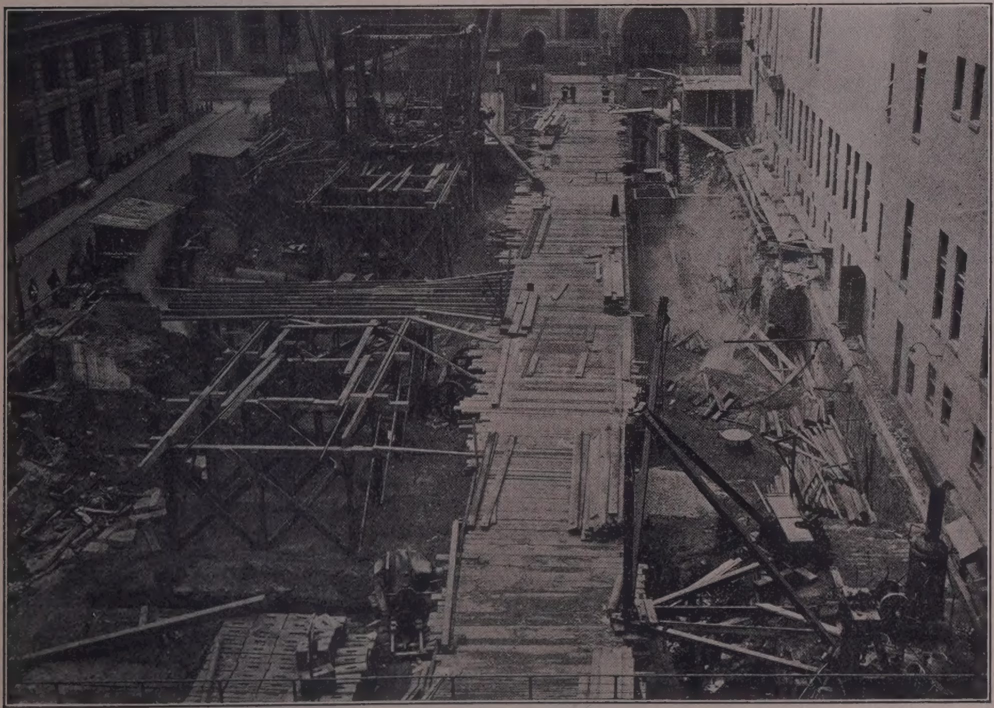
This provided a strip about 27½ ft. wide and 267 ft. long adjacent to the new Trinity Building called the Trinity Annex, and forming virtually a duplicate of the present structure. On the lot between Thames St. and Cedar St. a single building corresponding very closely to the enlarged Trinity Building, will be built on the extended site of the old Boreel Building. These two buildings will be essentially twin structures of nearly equal dimensions and the same architectural motive, and being so narrowly separated they will closely resemble a single building. Together they will contain 552,873 sq. ft. of floor surface and will be so arranged as to eliminate interior courts and give outside light and air to all office rooms, which it is expected will be ready for occupation early next summer. The contracts provide that the building shall be ready for tenants in one year from the first of last May, when construction was commenced. This requirement involves a large amount of extremely rapid work, including the erection of a very large quantity of structural steel, and the construction of one of the largest and most costly foundations in this city. The deep and difficult foundation work has already been completed in record time, and the erection of the steel superstructure has been commenced, a large plant installed and a sufficient force of men employed to push the work with great vigor.

After the old buildings had been wrecked to the cellar floor and the materials removed, the contractors for the new foundations commenced the cellar excavation and the removal of the old sidewalk vaults, some of the latter being, however, allowed to remain until the foundation work was sufficiently advanced to permit advantageous shoring and bracing, when the old retaining walls were removed. Excavation was commenced May 25 and was carried on by hand with pick and shovel over the entire 160x264-ft. area including Thames St. and Temple St. The space between the adjacent buildings will eventually be back filled, providing a solid embankment between retaining walls for Thames St. Temple St. was practically an alley between the cellars north and south of it, and this bank was removed with the remainder of the excavation, the spoil being loaded into wagons and drawn out of the lot on an inclined plane established at the southwest corner.

The old cellar floor was about 19 ft. below the Broadway curb and the excavation was carried down far enough for the new cellar floor, from 21 to 23 ft. below the curb, the groundwater level being 26 ft. below the curb. About 35,000 cu. yd. of earth, sand and old masonry were removed by a force averaging 300 men, working continuously, day and night, in successive eight-hour shifts. As fast as the excavation permitted, transverse framed falsework bents were set up in the bottom of the pit on the new center line of Thames St., and on them a 20-ft. platform of 3-in. planks was built to provide communication through the lot from Broadway to Trinity Place and afford a distributing and receiving platform, also used for loading spoil from the caissons to the wagons by which it was removed, and for unloading the caisson sections and materials used in construction.



View of Site with Caissons Under Pressure and Pier Forms Being Concreted.



Preliminary Operations; Building Platforms and Erecting Travelers.

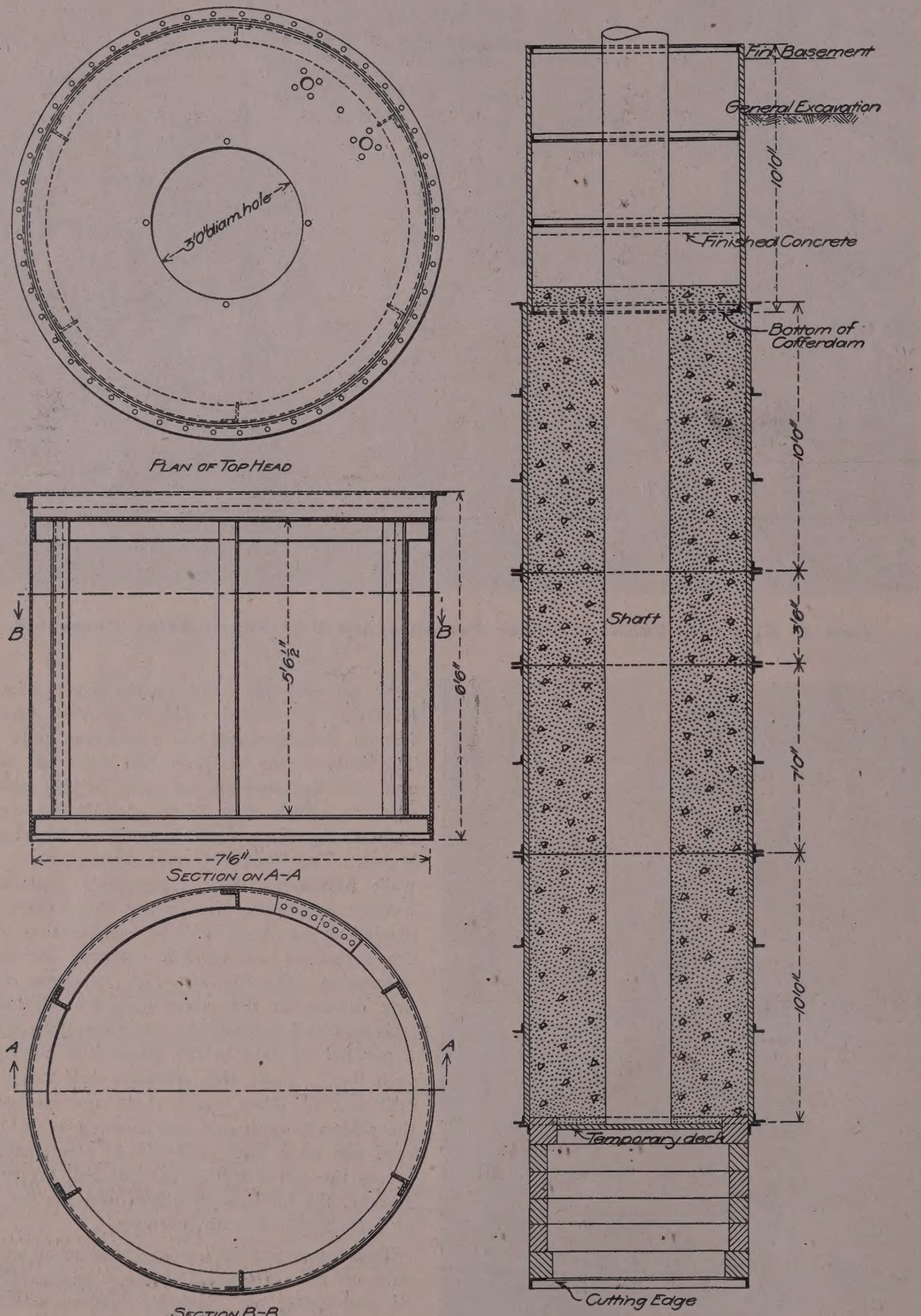
This platform was located between the wall columns of the Trinity Annex and the Boreel Building, clear of their foundation piers, so that it would not obstruct any of the building operations, and it will be retained for service purposes during the erection of the superstructure. The space underneath it was almost entirely occupied by sheds and portable buildings placed there to provide convenient offices, shops and storage, as indicated on the general plan. The Thames St. platform sloped downwards 14 ft. from Broadway to Trinity Place to correspond with the grade of Cedar St. Near its middle point, it was connected with Cedar St. by a similar transverse platform. This platform was built over one transverse row of piers, but care was taken to locate the transverse bents to clear the piers, thus enabling them to be constructed without interfering with the platform except by removing deck planks when necessary.

On each side of the transverse platform between Thames St. and Cedar St., falsework about 90 ft. long was erected to carry the 22-ft. gauge tracks for two tower travelers by which the foundation caissons and materials were handled. These falseworks were built on the center line of a row of caissons, the bents being spaced to clear the caissons. All of the falseworks and platforms were made with transverse bents of framed timber seated on transverse mud sills. The ends of the vertical posts were cut square and took bearings on the faces of the caps and sills, to which they were secured by wooden scabs or by the projecting ends of the diagonal braces. The Broadway and Trinity Place sidewalk pavements were temporarily replaced by wooden platforms. In Trinity Place these were carried at the street level by two lines of stringers supported on vertical columns set in the excavation. On Broadway, the platform was at first carried at the street level by one line of stringers and columns in the excavation and by a parallel sill laid in the street just beyond the curb line. Later this sidewalk was raised several feet to allow more room for working in the sidewalk vault and was covered by the usual roof and by a deck about 16 ft. wide extending across the full width of the lots and utilized for storage, the location of offices and for the track of a sheet-pile driving machine.

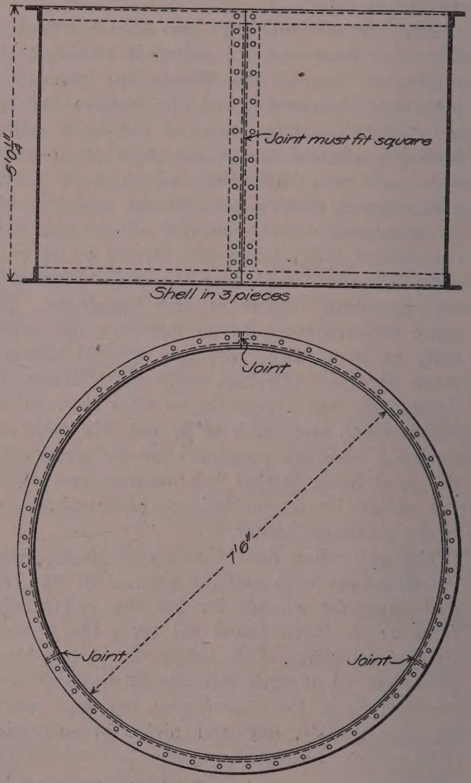
Two tower travelers were installed at an early date on the falsework tracks between Thames St. and Cedar St. Each of them was about 22 ft. square and 30 ft. high, made with double vertical posts at each corner between which were set steel masts with 40-ft. 8-ton wooden booms. The compression members of the tower were built of wood having steel connection plates at the principal points and braced with adjustable steel diagonal rods in the top and in each side panel. The masts were fitted with horizontal bull wheels for swinging, and each tower had four double-drum hoisting engines seated on its floor. Besides these travelers there were four stiff-leg derricks with booms from 30 to 60 ft. long, which were set in successive positions commanding all parts of the lots not covered by the travelers.

This installation provided in all twelve derrick booms and sufficed for handling all the materials.

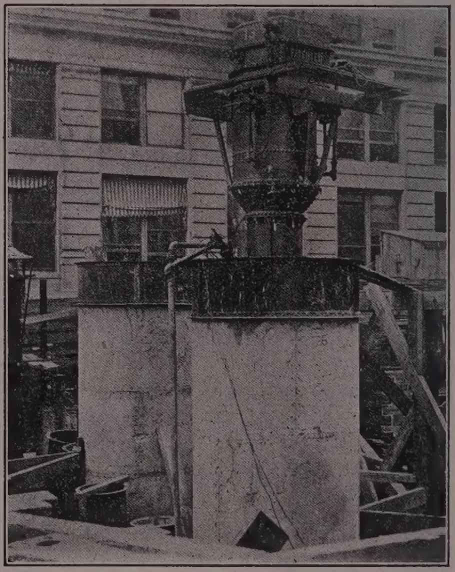
The columns for the two buildings are seated on 87 concrete piers carried to bed rock or hardpan by pneumatic caissons from 8 to 9 ft. square, except 28 cylindrical ones 7½ ft. in diameter for the intermediate piers in the Boreel building. The rectangular caissons were built of timber and were constructed and sunk substantially the same as those of the U. S. Express building and the Wall St. building for the Trust Company of America recently described in these columns.



Steel Caissons and Wooden Caisson and Sectional Concrete Form.



Section of Steel Form for Interior Pier.



Piers with Lower Sections of Forms Removed.

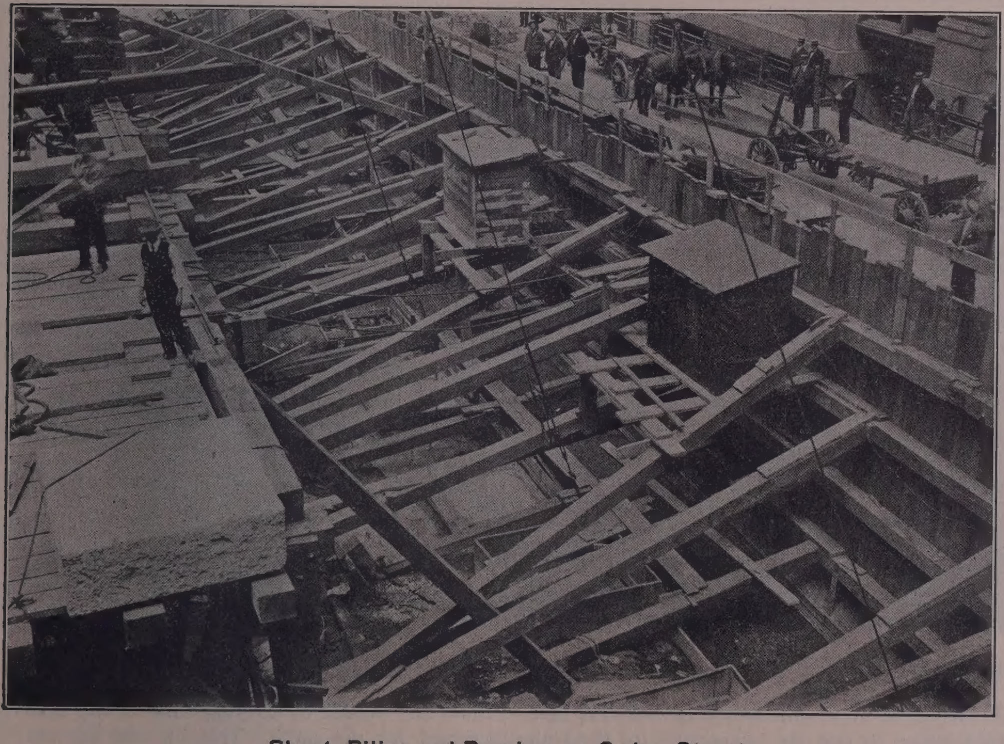
Each caisson had walls 6 ft. high made with solid courses of planed timber with vertical bolts from top to bottom. The intermediate courses were 9 in. thick and 12 in. high and the upper courses were 12 in. square. The lower courses were shod with heavy angle irons bolted on to form a cutting edge. The caissons had no permanent timber roof and were built complete at the contractor's yards and delivered on trucks at the site. They were unloaded and set accurately in position on the bottom of the pit by the stiff-leg or traveler derricks and were covered by temporary plank roofs supported by the upper courses of wall timbers and by temporary interior vertical shores.

Moveable wooden forms 3 ft. high were set on top of the caissons and in them 2 ft. of Portland cement mortar and concrete were placed and allowed to set a few hours until it acquired sufficient strength to carry itself and another course of concrete independent of the light roof planks which made the bottom of the concrete mould. A 7-ft. or 10-ft. section of the forms was connected to the top of the first section and the concrete was laid in it in successive 3½-ft. courses with intervals of a few hours between each course to prevent undue lateral pressure from a deep mass of wet concrete. After the lower portion of the concrete was thoroughly set, the forms were removed from it and placed on top of the upper sections of the form, thus continuously shifting from top to bottom and making three lengths of form suffice for each pier.

A temporary collapsible air shaft like those described in The Engineering Record of Oct. 27, was built in each pier and through it the material was hoisted freely while the excavation was carried down under atmospheric pressure to the water line. At this level an air lock was placed on the top of the shaft, air pressure was put on the working chamber and the excavation was continued until the caisson was sunk about 30 ft. and the top of the concrete was level with the bottom of the pit. Excavation was then discontinued until the concrete was carried up to nearly the full estimated height, when excavation was resumed and the caisson was sunk to solid rock or satisfactory bearing in hardpan at an average depth of 75 ft. below the Broadway curb.

The concrete forms were made with 2-in. plank bolted to horizontal angles about 3½ ft. apart, making single complete panels for each side. The angles projected beyond the edges of the panels and were provided with gusset plates riveted to their horizontal flanges with open holes for connection with the projecting ends of angles in the panels at right angles to them. The projections were long enough to furnish an adjustment enabling the widths of the panels to be varied one or two feet as required. The sides of the forms were secured by ¾-in. bolts passed through 1-in. tin tubes permanently bedded in the concrete that allowed the removal of the rods after the concrete was set. The horizontal angles at the upper and lower edges of the forms served as flanges for connecting the successive sections together. The tops of the piers terminated 10 ft. below the cellar floor and in order to provide for setting the columns and grillages on them, cofferdams made like sections of the forms were attached to the tops of the piers and served as retaining walls until after the steel work was erected, when they were removed and the space they had occupied was back-filled. The concrete forms were stripped before the caissons were sunk, after the concrete was 24 hours old.

The circular piers were made with cylindrical steel caissons 6½ ft. high, roofed with a horizontal flanged plate ¼ in. thick with connections for the concentric 3-ft. air shaft. An outside horizontal flange angle at the upper edge of the caisson received the corresponding lower flange of the first section of the concrete forms, which were made in 2½-ft. and 5-ft. lengths. Each length had three vertical joints made with outside flange angles. After the concrete was sufficiently set, the lower sections of the forms were stripped and replaced above in the same manner as for the wooden forms of the rectangular piers. After the caissons were sunk, the working chambers were concreted under pressure, the air shafts were collapsed and removed and the wells were filled with concrete completing the piers.



Sheet Piling and Bracing on Cedar Street.

The caissons were sunk to depths of 70 to 85 ft. below the Broadway curb and passed through red sand to the ground-water level, then through about 20 ft. of red quicksand containing a large amount of mica, 25 ft. of blue clay and quicksand, and hardpan of an average thickness of 6 ft. A few of the caissons were seated in the hardpan but most of them were carried down to the approximately level surface of the sound gneiss rock below it. The maximum air pressure was 30 lb. and the caissons were sunk by the weight of the concrete and by additional loads of 50 to 100 tons of ballast in the form of 2-ton cast iron blocks, much more easily and rapidly handled by the derrick than the usual pig iron or kentledge.

Air was first admitted to the caissons on June 20 and the last one was sunk Aug. 20, thus accomplishing the remarkable record of sinking 87 caissons in 60 days. The work was done by 21 gangs of five men working in seven 8-hour shifts, 35 sand hogs thus being continuously employed. As many as 14 caissons were under pressure at one time and 57 were sunk in 30 days. In quicksand a speed of as much as 2 ft. per hour was obtained in sinking but in hardpan this was reduced to about 1 ft. in four hours.

Air pressure was furnished by two Ingersoll-Sargeant and one McKiernan compressor with an aggregate capacity of about 3,000 cu. ft. of air per minute. Sometimes as many as 14 caissons were under pressure at once and required the full capacity of two compressors and part of the third, which was intended for reserve. Air was delivered from the compressors to a cylindrical water-jacketed cooler and thence distributed from a 6-in. outlet through three longitudinal lines of 4-in. main extending the full length of the lot and provided at frequent intervals with branches to the different caissons.

Concrete materials were received at Broadway and Trinity Pl. The stone and sand were chuted to storage piles in the bottom of the excavation and the bags of cement were kept in waterproof sheds above them. Two Chicago cubical 1-yd. concrete mixers revolving in outside geared rings and operated by independent engines were installed at opposite ends of the yard near the stone piles. At Broadway the machine was served by a stiff-leg derrick seated on the sidewalk falsework which also delivered the concrete buckets to the cars on the service track. At Trinity Pl. the materials were delivered by wheelbarrows to the depressed hopper of the mixing machine, and the latter was set at a sufficient elevation to discharge directly into steel buckets on flat cars.

In both cases the concrete was distributed to all parts of the work by a 24-in. Koppel industrial track running near the center of the lot between longitudinal rows of piers and provided in the middle with a turn-out, as indicated in the general plan. Switches were inserted at various points to allow branches to be extended to Cedar St., and were moved from time to time as the work progressed. At both ends of the line turntables were installed so that cars could be run across to a parallel line laid as required near the Cedar St. side of the lot. The traveler derricks and the stiff-leg derricks delivered the concrete from the cars to the caissons. The concrete was handled in twelve ½-yd. cylindrical steel bottom-dump buckets and by eight flat cars on the industrial tracks. Spoil from the open excavation was handled in twelve 1-yd. Stuebner steel buckets and in twelve ½-yd. special cylindrical buckets from the caissons.

Three sides of the lot were enclosed by a sheet pile retaining wall. On the Broadway front and on more than one-half of the Cedar St. front, the piles were of 4x12-in. yellow pine about 30 ft. long, the remainder were of United States patent steel sheet piles 27 ft. long. On the Broadway front they were driven by a 2,000-lb. hammer working in leads about 25 ft. high. The machine was supported on top of the sidewalk bridge. The remainder of the piles were driven by a Vulcan steam hammer working in leads about 25 ft. long suspended from the booms of the travelers or fixed derricks as was most convenient. On Cedar St., the sheet piles were driven against five tiers of inside rangers, three tiers of which were strongly braced by inclined shores with their feet engaging the foundation piers or the falsework for the roadway platforms.

At Trinity Pl., three columns of the Sixth Ave. elevated railway line were within the excavated area and were temporarily underpinned by the railway company. This was accomplished by supporting the ends of the main transverse girders on three longitudinal timber bents with their sills carried by steel girders blocked up from the surface of the street. These girders were about 30 in. deep and 20 ft. long, and their spans were great enough to permit excavation under them for the removal of the old foundation piers and the construction of new ones. For the new piers, sheeted pits were excavated to subgrade of the cellar excavation and in each of them five 12-in. extra heavy steel pipes with outside couplings were driven to hardpan by a pile-driving machine. The core was jetted out of the interior of the pipes and they were filled with concrete and above them and enclosing their tops was built a concrete pier about 18 ft. high and 8 ft. square at the base. At the top it was reduced to 7 x 6 ft., and received the base of the column which was seated on it and the underpinning removed.

The work was carried on day and night with a total force of about 850 men, organized in three principal divisions, mechanical, pressure and general, all of which were managed by foremen reporting directly to the superintendent. Steam for all power purposes was purchased by meter by the New York Steam Co., and electricity was furnished by the Edison Co., for about fifteen arc lights and a large number of incandescent lamps. Besides the plant already enumerated, there was also installed twelve double drum hoisting engines of Lidgerwood, and Mundy makes, one 6-in. Cameron steam pump and one 4-in. Brooks electric pump, besides many syphons and the ordinary equipment of small tools.

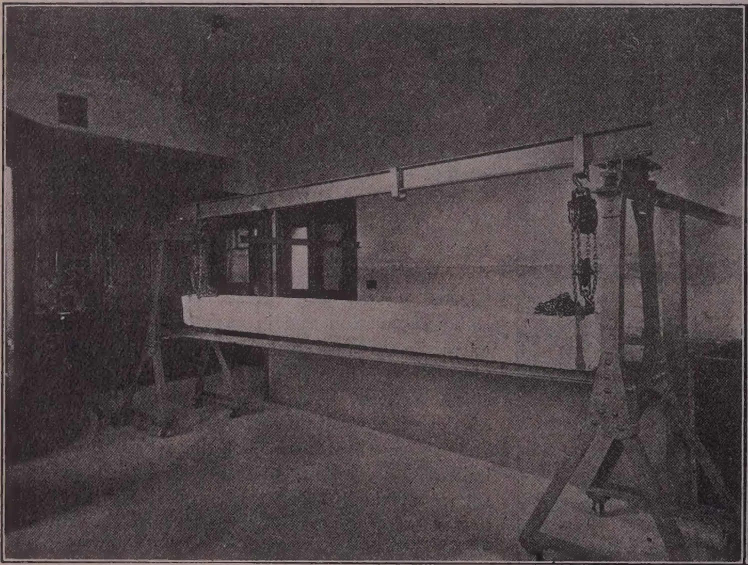
Mr. Francis H. Kimball is the architect of the buildings. The contract for the foundations was awarded to The Foundation Co., Mr. L. L. Brown, general superintendent, and Mr. H. J. Cole, superintendent in charge. The George H. Fuller Co. is the general contractor, and Mr. Byron W. Green was the contractor for the wrecking of the old building.

The New Cincinnati Water-Works are now ready to furnish about 12,000,000 gal. daily to the high-service system of the city. This supply is not filtered, as it will be some time before the purification works are built.

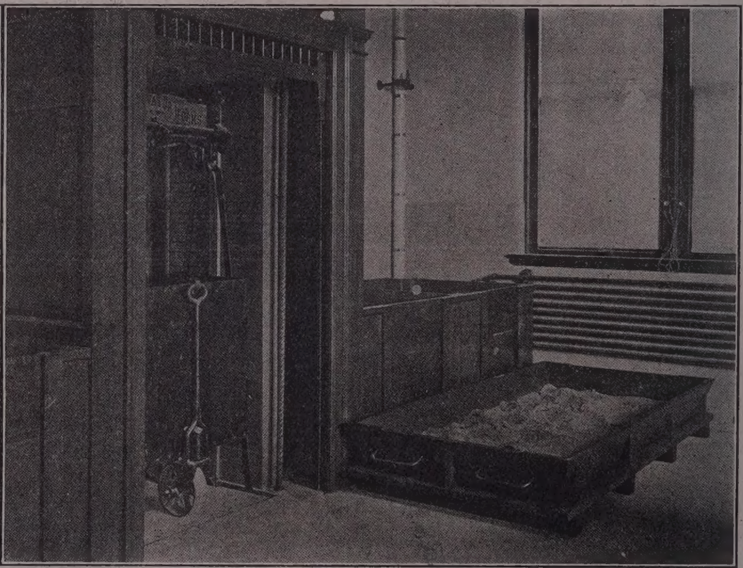
The Lesley Cement Laboratory, University of Pennsylvania.

A fortnight ago, in an article on the general features of the new engineering building of the University of Pennsylvania, an account was given of the cement laboratory it contains, the gift of Mr. Robert W. Lesley, of the class of 1871, who has been continuously identified with the manufacture of Portland cement in this country from its early days. The gift was made, to use his own happy expression, because he believed in the old adage of the farmers that a man should put back into the soil what he took from it. It was because of this conviction that a man who achieves success in an industry owes something to it which is best paid by providing facilities for its scientific study, that Prof. Edgar Marburg, head of the civil engineering department of the University, was given carte blanche to obtain all the apparatus necessary to make the laboratory complete in every respect for his purposes.

The accompanying illustrations give some idea of the laboratory, which consists of two rooms with a total floor space of 1,700 sq. ft., one for instruction in standard cement testing and the other for concrete work and research. In the instruction room there are four mixing tables large enough for sixteen students to use comfortably, four damp closets, eight balances and lockers and drawers for storing apparatus. The tables are shown in one of the accompanying illustrations, which also gives an idea of the general arrangement of this room. Each table is 7 ft. long and 5 ft. wide, made of red oak and provided with a slate top. In the center of the table is a soapstone damp closet, 2 ft. 6 in. long, 1 ft. 6½ in. wide and 1 ft. 1½ in. high, outside dimensions. It has zinc-covered pine doors closing against rubber gaskets, and cleats on which three tiers of movable shelves or trays can be placed. It is drained through a hole in the bottom which is kept closed by a rubber stopper; this hole is over an opening in the top of the table leading to a galvanized iron chute. On each side of this damp closet, there is a slate shelf raised 3 in. above the top of the table to hold the balances. Waste material is discharged through a chute in the center of each side of the table.



Crane and Tank for Beams.



Lift, Bins and Mixing Box.

Attention should be called to some special burettes mounted between the tables and connected to a water tank, through which water at a normal temperature may be quickly and accurately obtained. Each burette is 1 ft. 9½ in. high. The top 4½ in. has a diameter of about 2 in. reducing to 1 in. in a length of ¾ in., and this smaller diameter is continued for 13½ in. to the point where the graduations stop. Below this point there are two nozzles for connections to rubber tubes. The burette holds 360 c. c., and its lower portion is made of small diameter in order to gauge more accurately small quantities of water.

In addition to these mixing tables, there is a large one, also slate-topped, which is supplied with gas outlets and is used for special experimental work and for mounting smaller apparatus.

The bins in this room are twelve in number, arranged along one wall and surmounted by briquette storage shelves protected by glass doors. Each bin is 26 in. wide, 14 in. deep and 27 in. high, holding 1 bbl. of cement. It is closed by a hinged cover at the top and has a slide 6 in. square at the bottom of the front face. The bins and shelves are of oak, and several thousand briquettes can be kept in the latter.

Nine soapstone immersion tanks are provided in this room, each 6 ft. 7 in. long, 2 ft. 6¾ in. wide, and 9¾ in. deep. The sides and bottom are 1½ in. thick, while partitions of ½-in. slate are arranged in various ways in the different tanks. The tanks are supported in three tiers on frames about 7 ft. high and built of steel angle bars. Provision is made for supplying both hot and cold water, so that the temperature of the bath can be closely regulated, while the rate of flow through the tanks can be varied by means of adjustable overflow discharge connections. One of these tanks is supplied with 32 small zinc racks, each having three perforated shelves for the storage of briquettes.

A large soapstone damp closet is provided in this room for holding large briquette and beam molds, and there is also a large case for the storage of glassware and special apparatus, of which a great variety has been supplied by the donor.

For testing purposes there is an Olsen lever machine driven by an electric motor, a Riehle lever machine similarly driven, a Fairbanks shot machine and a Fulknau-Sinclair shot machine. The lever machines can be driven so as to apply the load at a uniform rate varying from 100 to 600 lb. per minute. Mention should also be made of an Olsen mechanical briquette molding machine, a Howard & Morse electrically driven sifting machine for cement and sand, and a Bauschinger expansion apparatus, which are placed in this room. The cement laboratory also has a 200,000-lb. universal testing machine as a part of its equipment, although this has been installed in an adjoining part of the building and not in the cement laboratory. It is an Olsen three-screw vertical machine fitted with a beam extension 15 ft. long, designed for a working load of 120,000 lb. It is operated by a direct-connected 5-h.-p., two-speed electric motor, and is fitted with an attachment for automatically recording stress-deformation diagrams.

The room devoted to research work has a standard mixing table like those already described, apparatus for accelerated tests, a drying oven, an immersion tank for beams, a molding block for preparing large test specimens, and bins and molds. The boiling apparatus for the accelerated tests is supported on a frame of steel angles, and is about 29 x 14 in. in plan. The drying oven is used in connection with tests to determine specific gravity and absorption. The immersion tank is made of concrete and is large enough to receive beams 13 ft. long. The tank is served by a special gantry crane 6 ft. high and 14½ ft. long, which has its side frames held rigidly such a distance apart that the cross beam can roll from them on to rails over the ends of the tank. This crane is used in taking the blocks from the tank to the 200,000-lb. testing machine.

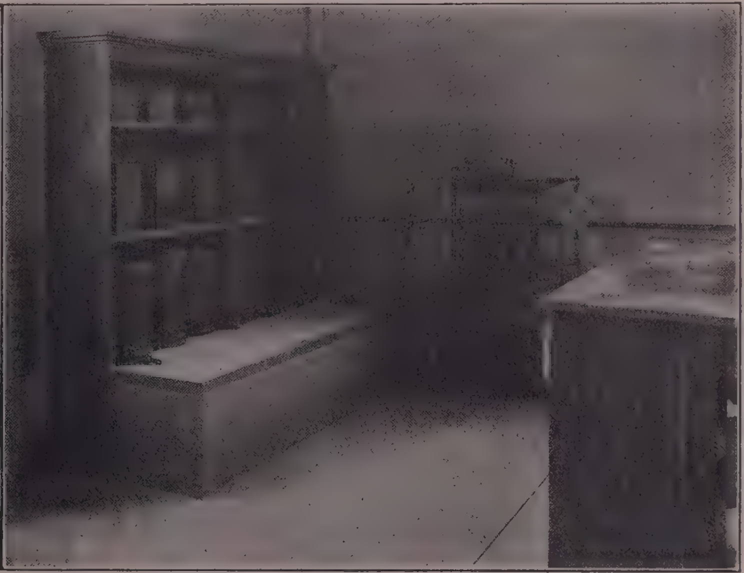
The material for the laboratory is delivered by means of a lift, and a steel car mounted on trucks and capable of carrying 1,200 lb. has been designed for use on it. This lift and car are shown in one of the illustrations, together with the mixing box and bins for materials. It might be added that the equipment of the laboratory includes molds for 8x11-in. beams 13 ft. long, and 8x8-in. beams 9 ft. long.

In the arrangement and equipment of this laboratory Prof. Marburg kept constantly in view the fact that it was primarily a part of the University's teaching plant. He consulted experienced specialists in testing cement and concrete, and brought together everything which was in any way desirable. In doing this he carried out the wishes of the donor, who desired that the laboratory should be not only a useful feature of the new engineering building, but should turn out young men equipped to take a part in the industry with which he has long been identified. It is appropriate in this place, indeed, to point out how thoroughly Mr. Lesley has been identified with the American Portland cement industry.

This association began when he was eighteen years old, and was working on the staff of the late George W. Childs, editor of the Philadelphia "Public Ledger." He had an uncle in Cumberland, Md., who had invested some money in a cement plant there. During the panic of 1873 the works became involved, and Mr. Lesley was asked if he could sell cement. With the brashness of youth he answered that of course he could sell some, and was shortly horrified to receive two carloads instead of the box of material for mending broken glass and crockery he had expected. The two carloads looked larger to him at that time than the whole output of the country does now.

Drawing out his savings to pay the freight, Mr. Lesley thus became engaged in the cement business in conjunction with Mr. J. W. Trinkle, a fellow clerk on the "Public Ledger." For several years both partners remained with the "Ledger," working at nights and early in the mornings to build up the business. Along in the early eighties the firm bought out the old cement and plaster house of Campbell, Harris & Co., and thus became one of the leading cement firms in Philadelphia. In 1882 Mr. Lesley was appointed manager of the Cumberland works at Cumberland, Md., and about this time he also was engaged in many experiments in the manufacture of Portland cement under the direction of Edward J. DeSmedt, then a government chemist at Washington, D. C. These experiments resulted in some fifteen or twenty patents, which were taken out covering many of the processes now in use for the manufacture of Portland cement in this country and in Europe.

Mixing Tables and Cement Bins.



Molds and Briquette Molding Machine.

Prior to this time, the firm of Lesley & Trinkle had become closely allied with David O. Saylor, of the Coplay Cement Co., the founder of the American Portland cement industry, were among his leading selling representatives, and in close touch with Mr. Saylor personally.

Along in 1883, believing that the Portland cement industry was the coming one in this country, Mr. Lesley walked from Campbell Hall on the New York State line, through the whole of the Lehigh region of Pennsylvania by way of Martins Creek, Bangor, Nazareth, Northampton, across the river to Coplay, and then back through the cement fields on the Ironton Railroad, where he ultimately purchased property and established the American Cement Co., which now has seven works in that vicinity. These works started to make cement under processes invented by Messrs. Lesley, Eckert, DeSmedt, Willcox and others and were a success from the beginning. Under the business management of Mr. Lesley and the mill management of Mr. Eckert, the company was one of the pioneers in the development of the Portland cement industry in this country.

During the early days of the industry there was exemplified the first case of "community of interest." Saylor, Bonneville, Navaro and Wellington were all beginning the manufacture of this important building product and the industry was undergoing all the diseases of childhood. The community of interest prevalent in the Lehigh Valley was the community of interest between the mill owners and the sheriff. It was touch and go as to who owned the mills from day to day. In those days, when a payment was made to any of the manufacturers, it was a common occurrence, between the receipt of the money and the deposit of the check in bank in order to meet pressing obligations, for the check to bear marks of fire caused by the friction in passing rapidly from hand to hand. The development of the industry was no doubt due to the hardships undergone by those connected with it in the early days, making for stable character and careful management.

Possibly the introduction of American Portland cement, as against the well-known foreign brands, was very largely due to Mr. Lesley who, by his acquaintance among engineers and his aggressiveness, was enabled to build up a reputation for the home product against the better established European brands. During the period covered since the first establishment of the American Cement Co., Mr. Lesley has had the pleasure of looking back over the growth of an industry whose output in the early eighties was 50,000 bbl. per annum, and is now close to 45,000,000 bbl.

In his scientific associations, Mr. Lesley is a vice-president of the American Society for Testing Materials; an associate of the American Society of Civil Engineers; a member of the American Chemical Society, the English Chemical Society and the Engineers' Club of Philadelphia, and a member of the National Advisory Board on Fuels and Structural Material. He was selected to read a paper on the development of the Portland cement industry at the International Congress of Engineers at St. Louis last year, and has been a voluminous writer on the subject of Portland cement. He was the first president of the Association of American Portland Cement Manufacturers, which he was largely instrumental in founding, and is on its executive committee now. At the present time he is president of the American Cement Co. of New Jersey, of which company he is also a director; he is president and director of the United Building Material Co.; president and director of the Lesley & Trinkle Co.; vice-president and director of the American Cement Co. of Pennsylvania; vice-president and director of the Bonzano Rail Joint Co.; president and director of the Reliance Cement Co., and an officer of other business corporations.

Interesting Bridge Shop Work.

Interesting bridge shop work is being done at the Pittsburg plant of the McClintic-Marshall Co., on the steel trusses for the New York Central & Hudson River R. R. Co.'s office building at 44th St., which was described in The Engineering Record of Feb. 24, March 17 and April 7. Between the third and fourth office floors, some of the columns support 42 transverse riveted trusses about 44 ft. long on centers and 14 ft. deep over all, which are designed to carry at their center points columns fifteen stories in height. The trusses are of massive construction weighing about 20 tons each, and each is composed of six pieces shipped separately from the shops, assembled at the site and field-riveted through pairs of large ¾-in. connection plates at panel points. The specifications require the holes for the ⅞-in. field rivets to be drilled through iron templates or to be sub-punched and the members assembled, reamed and match-marked at the shops. The latter alternative was accepted by the contractors and the trusses are assembled in groups of three in parallel vertical planes in the shipping yard. Two spaces are left between the trusses wide enough for the erection of falsework about 10 ft. high in each. On these falseworks longitudinal tracks are built for the carriages of special pneumatic drills, each having a single drill mounted in a rigid frame with vertical and transverse adjustments so that the horizontal drill can readily command any hole between given upper and lower vertical limits in a length determined by the length of the track on the falsework. The trusses are temporarily braced to the falsework for lateral stability and the machines travel from end to end of them reaming the holes in the top chord connections. The trusses are assembled and the drilling machines are handled by the traveling girder crane used for shipping which commands the position of the trusses. After the holes in one web of the top chord are reamed, the machine is shifted by the crane to another falsework on the opposite side of the same truss and reams the holes in the other web or the machine may be simply reversed on the same track and ream the holes in one web of another truss adjacent to the opposite side of the same falsework. Surface tracks run through and under the falseworks in the same vertical planes as the elevated tracks and machines on them simultaneously ream the holes in the lower chord connections of the truss. Two machines are now in use and are shifted from upper to lower tracks and turned horizontally as required by the traveling crane. This method utilizes standard machinery used in the regular shop work and has been found rapid and satisfactory for the purpose here described.

The Turbine Pump of the Montreal Water-Works.

There has recently been installed at the high-service pumping station of the Montreal water-works on McTavish St., a three-stage electrically driven turbine pump having a rated capacity of 5,000,000 imp. gal. per 24 hours against a total head of 110 lb. The pump, built under the Worthington patents, was designed by Mr. William Clinton Brown, consulting engineer of the John McDougall Caledonian Iron Works, and was constructed entirely by them. It contains several novel features to eliminate noise and vibration, and a special thrust bearing which is stated by Mr. George Janin, superintendent of the Water Department, to be operating very satisfactorily. The pump is direct connected to a 400-h.p. Bullock motor running at 620 r. p. m. under full load and operated from a 2,200-volt, three-phase, 60-cycle current.

This unit was tested for 24 hours last September by Mr. L. A. Herdt, representing Mr. Janin, and Mr. Charles Lester, for the makers. Calibrated ammeters, voltmeters and wattmeters were used to determine the current consumption, the amount of water was measured by a Venturi meter, the head of water was measured by a standard gauge and the temperature of the motor was determined by thermometers. Readings were taken every thirty minutes for the first six hours and every hour after that.

The water pumped during the first twelve hours amounted to 2,725,000 imp. gal. against an average pressure of 107.2 lb.; during the second twelve hours 2,745,000 gal. were pumped against an average pressure of 106.3 lb. The average electric horse-power consumed during the test was 421 h.-p. for the first half and 421.3 h.-p. for the second half. The maximum power developed was 438.5 h.p. when the pump was operating at a rate of over 5,800,000 imp. gal. per day.

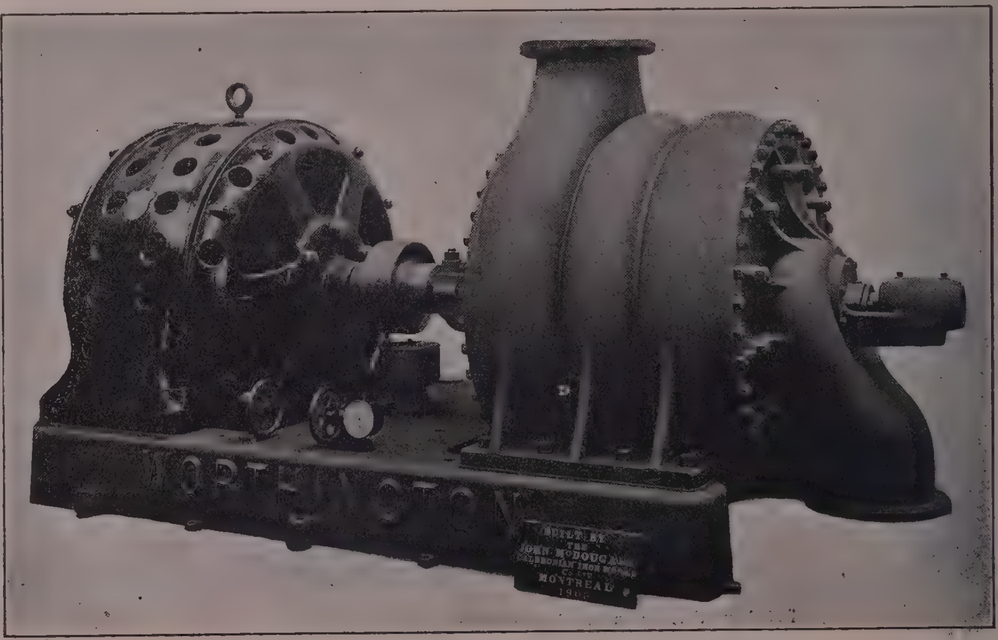
The overall efficiency of the pump when delivering 3,500 imp. gal. per minute was 65 per cent., with a discharge of 3,700 imp. gal., it was 66½ per cent., and with a discharge of 4,000 imp. gal. 67 per cent. The rise of temperature of the motor did not exceed 30° Cent. A noticeable feature of the pump shown during the test was an increase in its efficiency from 65 per cent. when running at its rated capacity to close on 69 per cent., when running above its rating; in other words, when pumping at its most economical capacity it showed an efficiency of nearly 69 per cent. As there is a Venturi meter with recording register, as well as a complete set of electrical instruments, in comission on this service, it will be possible to keep a constant supervision of operation of this pumping equipment.

The Headings of the tunnel crossing the Thames River diagonally from Rotherhithe to Shadwell met a short time ago, and it is expected that the work will be completed ready for use in about eighteen months. The tunnel has an inside diameter of 27 ft. and a length of 6,880 ft. It will have two sidewalks and a carriage way, supported on a horizontal partition which leaves below them a large subway for conduits and cables.

The Great Water-Works Project of Los Angeles.

It is probably correct to state that the water-works project which the city of Los Angeles has submitted to Messrs. F. P. Stearns, J. R. Freeman and J. D. Schuyler for criticism is the most noteworthy undertaking in water supply engineering now contemplated in this country. Its audacity is paralleled only by the pressing needs of the city, which has grown in population from about 50,000 in 1890 to 250,000 at present. This growth has not been a speculative boom, but marks a development expected by those familiar with the conditions in Southern California. This remarkable increase in population has put a great strain on the water-works, and numerous projects were suggested for increasing the supply. Finally the Water Commissioners retained Mr. J. B. Lippincott to co-operate with Mr. William Mulholland, superintendent of the water department, in making a thorough examination of all the available water resources in that part of the State. He showed that there was no large quantity of water to be had there, and this fact, which would limit the growth of the city, was being studied with the care it merited, when Mr. Frederick Eaton, ex-city engineer of Los Angeles, presented the advantages of Owens River, more than two hundred miles distant. Few places of such size would consider a supply from a source so far away, yet the engineers employed by the city found upon examination that it was the best to be obtained. The Water Commissioners accordingly secured about 40 miles of riparian property on the river and a reservoir site. These proceedings were conducted secretly, in order to prevent any speculative increase in the value of the property during the period of purchase, but were promptly ratified by a popular vote of 10,787 to 755, when the matter was presented to the people at a special election to issue $1,500,000 bonds for meeting the expense of securing the property, which had been bought by funds temporarily advanced by the Water Commissioners, and for beginning construction. Although the citizens have thus ratified the project, the Commission has deemed it wise, before asking for an authorization of more bonds, to have the plans reviewed by the three engineers named.

Messrs. Mulholland and Lippincott have summarized as follows the reasons for thus going more than two hundred miles from the city for a supply which will cost about $20,000,000 for its development:



High-Service Turbine Pump, Montreal Water-Works.

First. The water supply of the city and its suburbs is now maintained with difficulty by the use in part of temporary expedients. It will be necessary to obtain an additional supply, amounting to approximately 60 cu. ft. per second, within a period of twenty years, for strictly domestic purposes alone. The need for a greater domestic water supply is so urgent as to demand prompt relief.

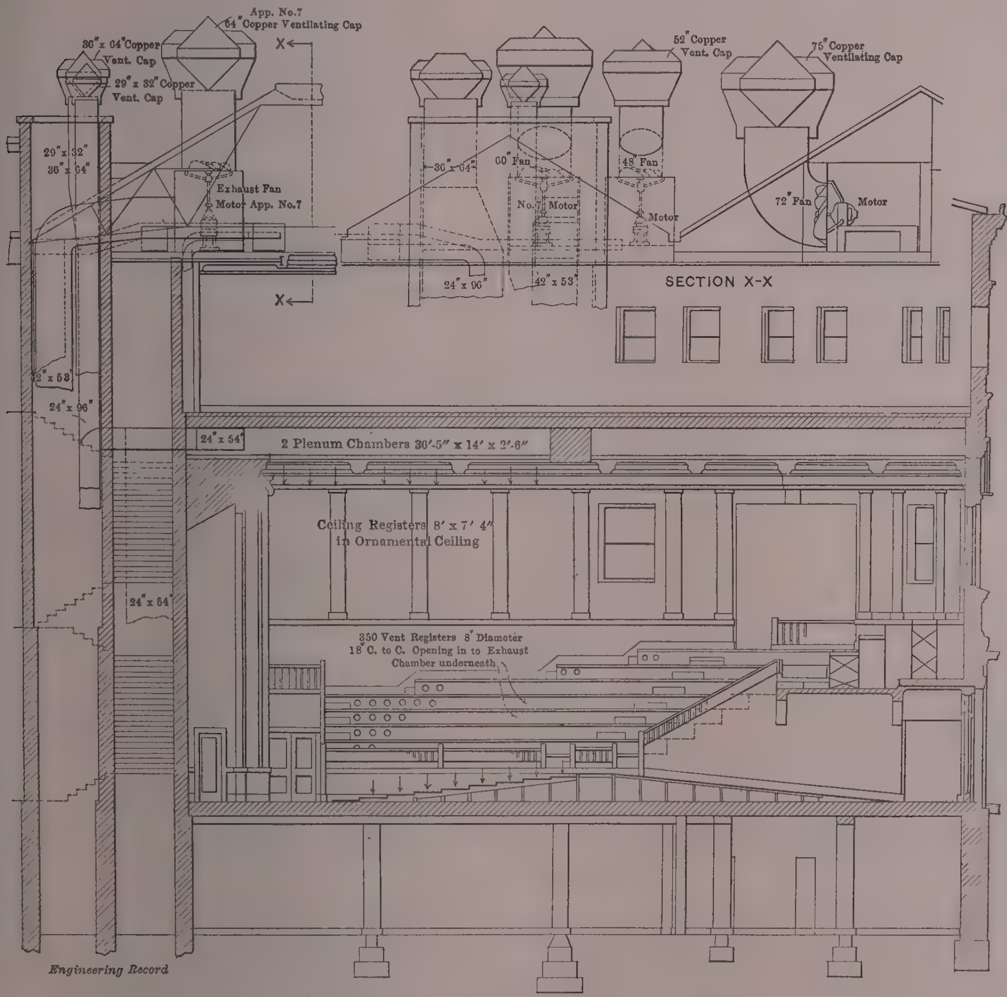
Second. It would not be wise for the city to endeavor to obtain its additional water from the gravel beds of Southern California, for these sub-surface waters are already over-appropriated and failing. The city could not obtain additional water from them without the expensive condemnation of highly developed horticultural districts, including many towns and villages. This manifestly should be avoided except as a last resort. It is not feasible to obtain an adequate supply from any of the streams of Southern California, although a partial relief could be obtained at a high expense by storing the flood waters of the Mohave River; this water should be used, however, in the San Bernardino Valley.

Third. Any waters to the amount of 500 second feet that can be obtained in addition to those actually needed for domestic consumption, could be used for the development of highly productive citrus foothill lands immediately surrounding the city, which, if properly irrigated, would soon support a dense suburban population.

Owens River, from which it is proposed to draw a supply, is fed by the melting snows of the high Sierras, and its average flow during the year is estimated at 325,000,000 gallons per day, ten times that of the Los Angeles River, from which most of the city's supply is now drawn. While the chief value of the Owens River project is an abundant supply of wholesome water, it has an additional advantage in presenting exceptional opportunities for the development of water power along the proposed line of the aqueduct. The point which now seems best suited for the construction of the first diversion works is 3,500 ft. above the elevation of the city hall of Los Angeles. It is estimated that at least 80,000 h.-p. can be developed along the aqueduct, so that the city could do its own public lighting from this source and have a large amount of current left for sale. The Water Commission believes that the revenue from this source, together with the net income from the water department, would be sufficient to meet, if not the whole, at least a substantial part, of the indebtedness to be incurred by the city in carrying out the project.

Mechanical Equipment of the Carnegie Library Extension, Pittsburg, Pa.—III.

Exhaust Ventilation.—In the ventilation of the Carnegie Library Extension, the provisions for fresh air supply are supplemented by exhaust ventilation in all parts of the building, except the Architectural Hall. An exhaust equipment has been installed for this purpose of capacity somewhat in excess of that for delivering fresh air, even though exhaust from the Architectural Hall is omitted and a number of rooms have supply equipments of capacity in excess of those for exhaust, for the purpose of maintaining plenum within them. The total combined exhaust capacity is over 650,000 cu. ft. per minute, distributed among 30 fans, of which a considerable portion is for toilet rooms, which have exhaust ventilation connections only.


App. No.7
64" Copper Ventilating Cap
36" x 64" Copper Vent. Cap
29" x 32" Copper Vent. Cap
X
52" Copper Vent. Cap
75" Copper Ventilating Cap
29" x 32"
36" x 64"
Exhaust Fan
Motor App. No.7
36" x 64"
60" Fan
No. 7 Motor
48" Fan
Motor
72" Fan
Motor
24" x 96"
42" x 53"
SECTION X-X
X
42" x 53"
24" x 96"
24" x 54"
2 Plenum Chambers 36'-5" x 14' x 2'-6"
Ceiling Registers 8' x 7' 4" in Ornamental Ceiling
24" x 54"
350 Vent Registers 8" Diameter 18" C. to C. Opening in to Exhaust Chamber underneath
Engineering Record

Details of Ventilation of the Lecture Hall and Typical Exhaust Fan Arrangement in Attic.

In arrangement of apparatus stations, the exhaust fan equipment differs widely from that of the fresh air equipments which, for convenience of intake and filter arrangement, were distributed in three general groups. The exhaust fans, while bearing the same station numbers as the supply fans in accordance with the rooms or portions of the building from which they exhaust, are more generally distributed throughout the building, either in the basement or attic, as proved most convenient for duct connections and discharge. The equipments of systems 1, 2, 5, 8, 9, 10, 12, 13, 15 and 21, serving some of the large rooms on the lower floors, are located in the basement, but the greater part in the attic in convenient positions relative to the exhaust riser ducts and short discharge connections through the roof. For a number of the systems several fan equipments are used, one having as many as five, entirely in accordance with the character of the departments supplied and the extent of occupancy. While the fresh air supply stations in no case have more than one supply equipment, located at one point, it was found expedient to subdivide the exhaust equipments of certain stations in order to simplify connections and avoid long duct lines.

Exhaust Fans.—Disc fans were used for all of the exhaust systems where conditions of duct arrangement and discharge connections were favorable, offering little resistance to the flow. There are 21 equipments of this type installed, all but two of which are located in the attic and draw through vertical vent flues from below and discharge through roof discharge hoods. In nine cases, however, long gathering duct lines and the necessity of discharging through long vent risers made the centrifugal type of fan necessary; all but one of the centrifugal exhaust fans are located in the basement and serve extended duct systems. The purposes, sizes and capacities of all exhaust fans are indicated in the table published last week in the article descriptive of the fresh air supply. equipments.

The centrifugal exhaust fans are in all details of construction similar to the centrifugal blowers used for the fresh air supply systems. The disc fans are of the usual Blackman type, and the greater part of them are arranged vertically, with drives from vertical shaft motors arranged directly underneath. These fans have the usual two-hub construction; from one hub radiate spokes, carrying the blades and connecting with a tire, while from the other hub ribs extend to reinforce the curved edges of the blades. Each fan is mounted within a circular ring with three or more arms which support the shaft bearings. These fans are, like the supply fans, driven by C. & C. multipolar direct-current motors. The motors are operated through speed-controlling starting boxes which are fitted for a speed control ranging from two-thirds to full speed through field regulation. The centrifugal exhaust fans were, together with the supply fans, supplied by the B. F. Sturtevant Co., Boston, Mass., and the disc fans by Howard & Morse, New York.

Fan Locations.—The centrifugal exhaust fans of stations, Nos. 1 and 2, which serve the front portion of the basement, portions of the main floor corridor and the foyer, are located in a convenient position underneath the architectural hall for short direct connections to vent risers in an adjoining pipe shaft for discharge. Each exhausts from the rooms served through extensive lines of duct work carried on the ceiling of the basement, as shown in the basement plan published on Oct. 20. Station 5 has a centrifugal exhaust fan serving the engine room, which is in the library basement at the west end of this room, convenient to ductwork connections and for discharge through a vent riser in an adjoining pipe shaft. The centrifugal exhaust fan of systems 8 and 10, which are located underneath the lecture hall, discharge through riser ducts in a common pipe shaft at the rear of the lecture hall, fan 8 having a two-duct intake from the vent space underneath the floor of the lecture hall, while fan 10 has both overhead and underground duct connections from the kitchen and restaurant in an adjoining section of the basement. Centrifugal fan 9, serving the book-stack room, is installed beside the fresh-air fan supplying that section, and drawing from a downtake connecting with the vent registers on the upper floors, discharges into the adjacent interior court 2. Centrifugal exhaust fan 13 serving the music hall is located in the basement, drawing from an exhaust chamber with a multiplication of intake ducts leading to floor and wall vent registers, and discharges through a riser in an adjoining interior court of the building. System 15 is a localized system of small size, serving building A, in which are housed the alcoholic specimens of the museum.

The disc fan operated vent systems are, as above stated, for the greater part located in the attic, where connection could most easily be made to vent risers. The subdivision of equipments was due in part to the great size of the building, but more to the varied purposes for which the rooms served will be used. In all departments of the building some portions will be used more constantly than others, for which reason many of the systems were designed with special reference to temporary service at infrequent intervals. The disc fans of systems 3 and 4 are located in the attic in the front portion of the building where they are most convenient to duct connections from the sculpture hall and art galleries, respectively, which they serve. Disc fan 6 and the five fans of system 7, which exhaust from the various parts of the large museum, are distributed in different portions of the attic above it, where most convenient to the exhaust riser ducts. Stations 11 and 12, serving the south and west wings of the library, have each a disc fan in the attic, while the latter has also a disc fan in the basement which serves a system of exhaust ducts from small rooms of this department on the main floor. Systems 7 and 11 are exceptions in that they exhaust through extensive gathering ducts in the basement, connecting with rooms on the first floor. The music hall has an auxiliary disc exhaust fan in the attic which was installed for special ventilation of the upper gallery of the music hall. The remaining six disc fans are for exhausting from the toilets and are in the attic with the exception of No. 21, serving the music hall toilets, which is in the basement.

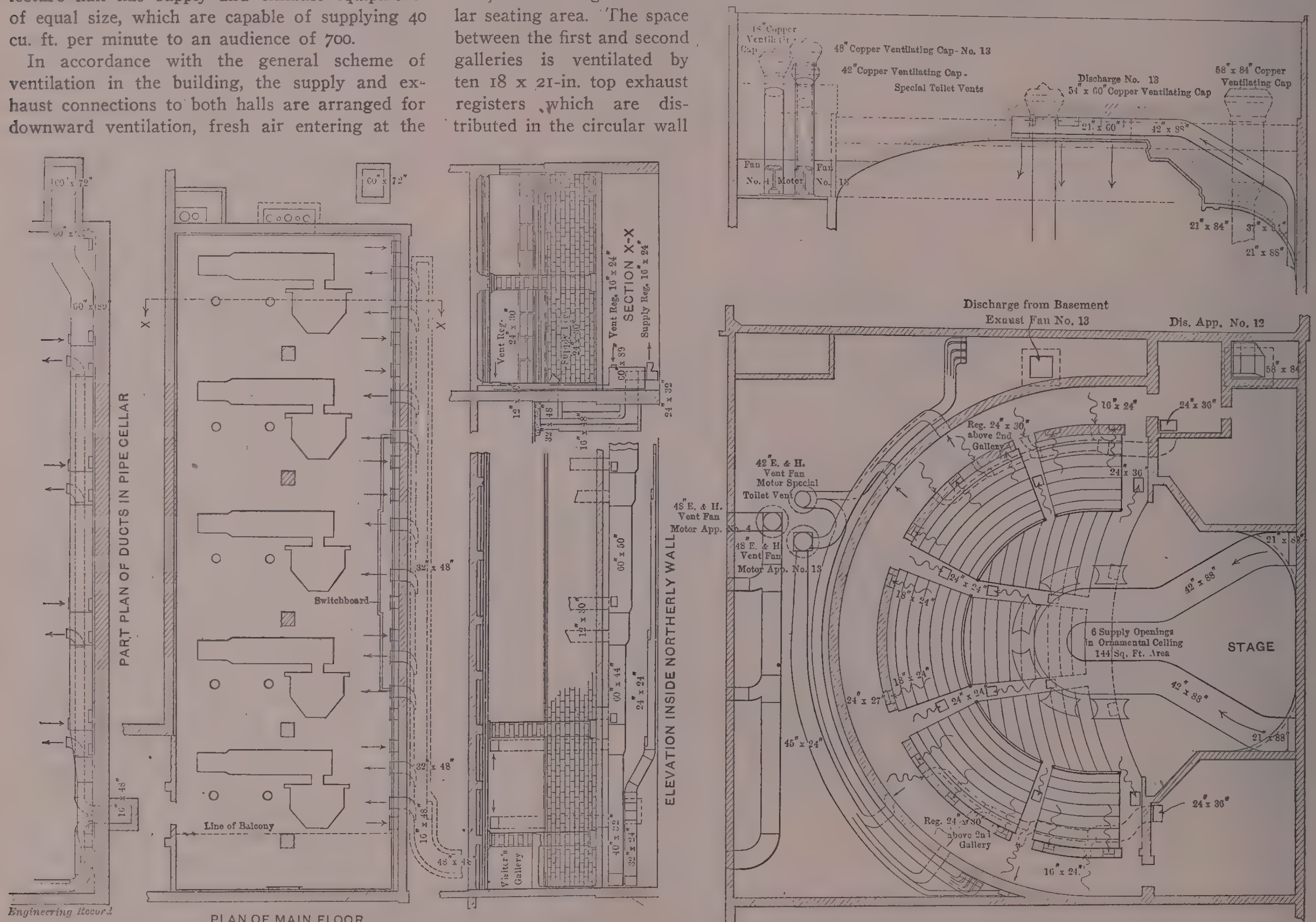
Music Hall and Lecture Hall.—In the ventilation of both the music hall and the lecture hall, problems analogous to theater and public hall ventilation were encountered. The music hall is of typical theater construction, while the lecture hall is an ampitheater with high ceilings, a stage and sloping floors with terraced seats. The former is utilized for concerts and musical entertainments, seating 2,100 people in both the main floor and galleries. The lecture hall seats about 600, and is intended for class lectures for students. The ventilation in the music hall has been designed on the basis of a supply 30 cu. ft. of fresh air per minute per occupant, with a capacity of exhaust ventilating equipment slightly less, effecting a plenum within the hall. The lecture hall has supply and exhaust equipments of equal size, which are capable of supplying 40 cu. ft. per minute to an audience of 700.

In accordance with the general scheme of ventilation in the building, the supply and exhaust connections to both halls are arranged for downward ventilation, fresh air entering at the ceiling and being removed through floor registers. The fresh air supply to the music hall is from equipment 13 through a basement distributing duct of 21 sq. ft. cross-section, which, at maximum duty, provides a velocity of 50 ft. per second. This leads to two riser flues at the rear corners of the stage, each 21 x 88 in. in section, each of which expands above the ceiling finish into 42 x 88-in. ducts for reduction of flow velocity to approximately 1200 ft. per minute. These are extended over the center of the auditorium to six delivery outlets in the ceiling, and the branch connections to these outlet registers are also proportionately increased in area for further reduction of the delivery velocity. These six openings having an aggregate area of 144 sq. ft., which, at the full capacity of the supply fan, brings the delivery velocity down to about 450 ft. per minute. This comparatively high delivery velocity is not, however, objectionable, owing to the 75 ft. height of the ceiling at this point above the floor, and the fact that the galleries are situated somewhat to the rear of this center to supply, so that the incoming air has an ample opportunity to spread and diffuse before reaching the audience.

The vent connections for removal of foul air from the music hall consist of registers in the main auditorium floor and in the wall underneath the galleries. The floor registers are twelve in number, consisting of four 24 x 36-in. registers located immediately in front of the stage and eight registers, 2 ft. square, distributed in the aisles. For the ventilation of the confined spaces under the galleries, there are under the first gallery, twelve 18 x 24-in. top wall registers facing the auditorium and eight 16 x 24-in. wall registers opening into the corridor at the rear, surrounding the circular seating area. The space between the first and second galleries is ventilated by ten 18 x 21-in. top exhaust registers which are distributed in the circular wall at the rear. These registers, which together provide a total combined area of exhaust openings for the auditorium of 124 sq. ft., connect through gathering duct lines to an exhaust chamber in the basement underneath the auditorium floor, from which the 9-ft. centrifugal exhaust fan draws. This fan has a maximum capacity of 50,000 cu. ft. per minute, at which duty the velocity of inflow at the registers is about 400 ft. per minute. The space above the second gallery has special provisions for ventilation in cases of unusual crowd in the hall, consisting of a 48-in. disc fan in the attic above, which exhausts 13,000 cu. ft. per minute through five 24 x 30-in. registers in the upper rear wall; this is intended to prevent a vitiated condition of the air in the upper rear portion of the room, which is, in fact, out of range of the circulation of air from the fresh air supply outlets in the central portion of the ceiling. The total capacity of exhaust ventilation is thus slightly less than that of the supply, which provides for a slight plenum within. The design of the music hall equipment was planned for about ten changes of air per hour.

The lecture hall is without galleries and has a much lower ceiling, the maximum head-room in the central portion of the auditorium being about 34 ft. Some difficulty was experienced in arranging for the supply through the ceiling at this height in order to distribute effectively the incoming air and prevent drafts on the audience. Delivery is made through a number of registers in the ceiling of ample area to permit very low velocities of delivery. The supply to these is furnished from the 7-ft. fan in the basement through two 24 x 54-in. ducts in riser shafts at the rear of the rostrum to two plenum chambers above the ornamental ceiling from which the registers open. These chambers are each of No. 18 galvanized iron, 36½ ft. long, 14 ft. wide and 30 in. deep, and each supplies three registers, 7 ft. 4 in. by 8 ft. in area, which are partly concealed by the ornamental ceiling finish of the room. The six registers have thus a combined area of 352 sq. ft. which permits of a delivery velocity of not more than 80 ft. per minute at maximum capacity of the supply fan.

The exhaust ventilation of this room is accomplished, like that of the music hall, through floor registers served by the exhaust fan in the basement. The registers are here, however, universally distributed, consisting of 8-in. circular openings which are spaced on 18-in. centers in the floor underneath the rows of chairs in the central portion of the seating and in the risers of the terraced seating at the rear. These open directly into a large exhaust chamber built under the floor, from which connection is made at two points through 20 x 72-in. ducts to exhaust fan 8. There are 350 of these vent registers which, having a combined area of over 120 sq. ft., provide



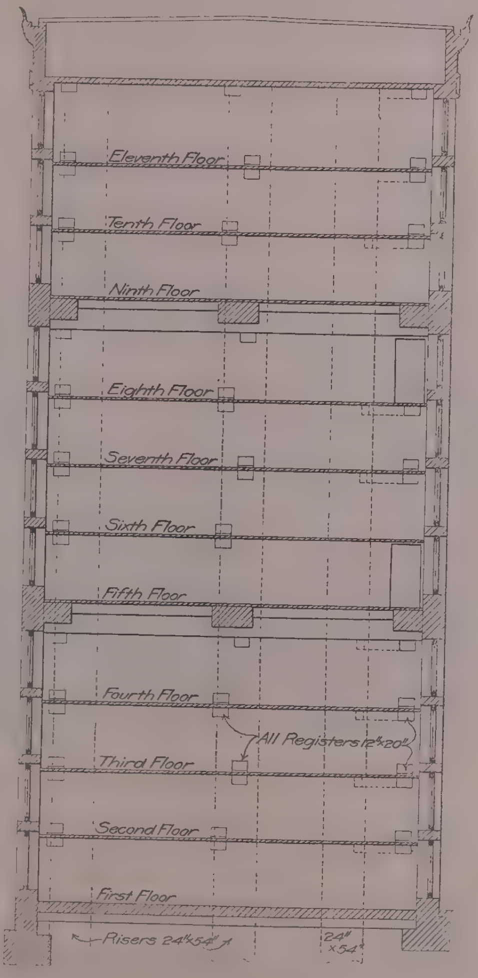
Ventilation of the Engine Room and Pipe Cellar and Arrangement of Ventilation Connections to the Music Hall.

for an average exhaust velocity into the registers of about 230 ft. per minute at the full capacity of the fan. In this hall, the capacities of supply and exhaust fans are the same, the design providing for about 12 changes of air in the room per hour.

Book-Stack Room Ventilation.—The book-stack section of the building is a wing 40 x 120 ft. in plan and contains eleven floors, rising to a height of 84 ft. above the first floor level. The ventilation system of this room has been designed with particular reference to the conditions most favorable to the preservation of books. All of the windows are hermetically sealed and all fresh air supplied is passed through an air washing apparatus, described last week, the capacity of the supply equipment being considerably in excess of that for exhaust, in order to provide for a plenum within, which measure was resorted to as the most effective means of eliminating dust and dirt from the room. The fresh air is furnished by a 10-ft. centrifugal fan in the basement, which has an intake through air-wash apparatus and discharges through a group of distributing ducts under the floor. This ductwork consists of a 60 x 57-in. main duct, which delivers into two 36 x 54-in. branches, one leading toward either end of the book-stack room. At the south end, three 24 x 54-in. riser ducts are supplied which are carried up to the outlet registers on the various floors. At the opposite end of the room, the underground duct branches into one 34 x 36-in. and two 12 x 30-in. ducts, the former delivering to a 42 x 60-in. riser duct in an adjoining pipe shaft and the two smaller branches to six 10 x 12-in. individual risers in the northerly wall of the room. The supply registers on all floors are 12 x 20-in. in area and in all cases except where construction prevented, there are three of these at both floor and ceiling lines at either end of the room. There are in all 53 of these registers in either end wall of the book-stack division of the building, 31 of which are at the ceilings of the various floors and the remaining 22 at the floor line, distributed as shown in the accompanying wall elevation. Those in the south wall are fed by the three 24 x 54-in. risers, while in the north wall eleven are fed by each group of 10 x 12-in. risers and the remainder by the 42 x 60-in. duct in the adjoining pipe shaft. The principal feature of this system of supply is the distribution of practically duplicate arrangements of supply outlets at floor and ceiling lines on all floors of the wing, those at the ceiling being intended for the air supply under all normal conditions, while those near the floor are installed for the purpose of cooling in summer time. This was considered essential, as the windows are hermetically sealed and only in this way could direct drafts be obtained in hot weather, for the comfort of the attendants. The capacity of the equipment is comparatively small, providing for but six to eight changes of air in the wing per hour, and the outlets are designed for delivery velocities of 300 to 500 ft. per minute, according to the number of registers in use.

The exhaust ventilation of the book-stack section is provided by wall registers near the floor line in the middle portion of the west wall of the wing. Connections are made from these to the exhaust fan in the basement by two lines of rising ducts, each 36 x 54 in. in section, which are carried full size up to the eighth floor, reducing above that to 15 x 36 in. and at the tenth floor to 18 x 20 in. Each duct connects with eleven 18 x 20-in. exhaust registers, one upon each floor, which at the full capacity of the fan effect a velocity of intake of over 700 ft. per minute. The vertical exhaust ducts join in the basement into a 5 x 8-ft. connection to the exhaust fan, the latter discharging directly through a short connection, into the adjacent interior court, No. 2.

Sculpture and Architecture Halls.—In both the sculpture and the architectural halls special problems were encountered in providing for the delivery outlets, owing to ornamental finish of the interior preventing a convenient arrangement of duct work. The outlets for fresh air supply were concealed in the cornices of the ceiling finish around the edges. The architectural hall, which is 60 x 150 ft. in plan and has an interior height of about 65 ft., has sixteen supply register openings, each 15 x 24 in. in size. These registers are supplied by two 45 x 64-in. risers from the basement supply fan connections to distributing ducts carried in the large space between the domed lights and skylight above the hall. The sculpture hall is similarly supplied through four 30 x 48-in. registers, two at either end of the room, which are supplied by a separate 16 x 45-in. riser from the basement. These supply registers in both halls are designed for comparatively high velocities of delivery, ranging up to 700 ft. per minute at the maximum capacity of the supply fan, but owing to the height of the outlets this is not objectionable.



Supply Connections to Book Stack Wing.

The architectural hall is entirely without exhaust ventilation connections, as owing to the large openings into adjoining corridors and rooms, ample exhaust provisions are made through the systems of adjoining rooms. The sculpture hall has, however, exhaust ventilation operated by the 4-ft. disc fan in the attic space above the architectural hall. This fan serves a system of gathering ducts, connecting with 16 x 27-in. wall registers near the floor, of which there are eight provided, four on either side of the room.

An interesting provision of ventilating equipment for preventing the intense heating effect of the skylighting in the summer has been installed, consisting of disc exhaust fans which exhaust from the spaces between the domed lights and the main skylights above all of the sections of the buildings fitted with this sort of lighting, embracing the architectural hall, the sculpture hall, the art galleries, portions of the museum, and a number of study rooms on the third floor at the southerly end of the building. The air in the enclosed spaces between the domed lights and skylighting is apt to become highly heated by the sun in hot summer days with resultant unpleasant heating effect in the rooms below. This is obviated to a large extent by connections from the exhaust fans which enable the air to be circulated in these spaces.

Engine Room Ventilation.—Special attention was given to the problem of adequately ventilating the engine room, a 46 x 140-ft. sub-basement room with 25-ft. headroom, underneath the central portion of the building, and a pipe cellar with 12-ft. clear headroom underneath. Cold fresh air is supplied to this division by the 7-ft. No. 5 supply fan, while the heated air from the machinery is exhausted by the 8-ft. exhaust fan in the basement under the library adjoining, at the westerly side. This air supply is untempered, as heating is not required in the engine room, and also the usual arrangement of downward supply is here deviated from, fresh air being supplied at points near or a few feet above the floor level, while the air heated to high temperature by the steam-using machinery is exhausted through registers at the top of the rooms. The fresh air supply to the engine room is less than that for exhaust, in order to effect a vacuum which will tend to prevent the escape of heated air from this division into the corridors or other portions of the building.

The cold fresh air is delivered from the supply fan by a 48 x 48-in. duct under tthe basement floor to a distributing duct under the floor of a corridor adjoining the engine room on the north side, from which the delivery outlets are supplied. This distributing duct is 32 x 48 in. in section and supplies air to ten 12 x 30-in. branches which open into the engine room through 24 x 30-in. registers. These branch ducts are carried through the engine room wall and at the outlets are inclined downward at an angle of 45 deg. These openings are all so spaced as to deliver directly against each of the engines and generators of the five direct-connected electrical units. These supply outlets are designed for comparatively high delivery velocities, each discharging at full capacity of the supply fan, 2,400 cu. ft. per minute, at a velocity of approximately 500 ft. per minute. For the supply of air in the pipe cellar underneath the engine room, a 16 x 48-in. branch is taken from the fan delivery duct tó a second distributing duct on the floor at the front of the cellar. This connection divides in the cellar into two branches, each 32 x 24 in. in section, one of which extends the length of the cellar and the other off to the rear into an L-extension under another portion of the building. Each of these branch ducts has four delivery outlets, each of which is 8 x 24 in. in section and supplies 1,500 cu. ft. per minute. All of these outlets are enlarged to register openings 16 x 24 in. in area, by which the delivery velocity is reduced to about that of the engine room registers.

The arrangement of exhaust connections in the engine room and pipe cellar is similar to that for supply, excepting that the exhaust openings are all located near the ceiling line. The exhaust fan in the library basement draws through a 60 x 95-in. underground galvanized-iron duct, which is carried through the pipe cellar immediately above the fresh air-supply duct for that room and decreases in section as branches are taken off. The duct has eight intake openings in the pipe cellar, each an 8 x 24-in. branch with a 16 x 24-in. register, and in addition has ten branch riser connections leading to wall registers near the ceiling of the engine room and four branches carried up to the pump room section of the L-extension from the engine room. The ten branches to the engine room are 12 x 30-in. ducts with 24 x 30-in. vent openings, while those for the pump room are 8 x 16-in. branches. The design of this duct system and the proportions of register area are such as to provide for velocities of intake similar to the register velocities in the engine room, which average 500 ft. per minute. The exhaust discharge riser, 48 x 54 in. in section, is carried up to the roof through a pipe shaft at the end of the engine room and is covered with 1 in. magnesia blocks, wired on and encased with 10 oz. canvas, this being, in fact, the only exhaust duct with insulation covering.

The ventilating equipment of the Carnegie Library Extension was designed by Baker, Smith & Co., New York, and installed by their Pittsburg branch. The architects of the building were Alden & Harlow, Pittsburg, Pa.

(To be continued.)

Balanced Draft Furnaces.

The balanced draft furnace for steam plants which has been installed in a number of buildings and industrial plants during the last year has produced savings of 7 to 44 per cent over the fuel charge of the same boilers previous to their alteration, according to a paper read by Mr. Embury McLean before the Brooklyn Engineers' Club. The draft is balanced by throttling the suction of the chimney in proportion to the speed of a fan supplying air to the ashpit, the speed of which is governed by variations in the boiler pressure. The fuel is fed by a mechanical stoker at a rate which is also controlled by the variations in the boiler pressure. In this way a constant ratio of air to coal is maintained for all rates of combustion. The stoker and furnace have been designed to feed the coal in such a manner that the heat liberates the moisture and volatile matter, which combine with the requisite amount of air, heated to the temperature of combustion essentially as in a producer gas furnace. The carbon is then consumed on inclined grates of large area.

Fire Losses due to the deficient water supply furnished by a private company were recently the subject of a case before the Pennsylvania Supreme Court, which decided, like the courts of most other States, that where a water company has agreed with a township to maintain hydrants and an adequate supply of water for fire purposes, though the company was negligent in furnishing such water, it was not liable to a resident of the township for a loss from fire.

The Remarkable Settlement of a Concrete Building in Tunis.

By P. Fountain, Chicago.

Since the establishment of the French Protectorate over the Beylik of Tunis, its capital of the same name has never ceased to grow in size, population and wealth. While the original Arab city occupied and still occupies the higher and firmer ground, the new French extension spreads from this in the direction of the Bahira or Lake of Tunis, to the modern port which, by means of a canal constructed at a cost of many millions of francs, traverses the shallow and silting lake and debouches in the sea at Halg el Dued, La Goulette, the former port. This flat stretch of land, some miles broad, on which the French town is built, is in the last degree marshy and unstable, a terror to architects and builders, and wonderful are the directions from the perpendicular and the horizontal which many of the structures, for the most part temporary, exhibit, collapsing into X-like or bulging into O-like forms.

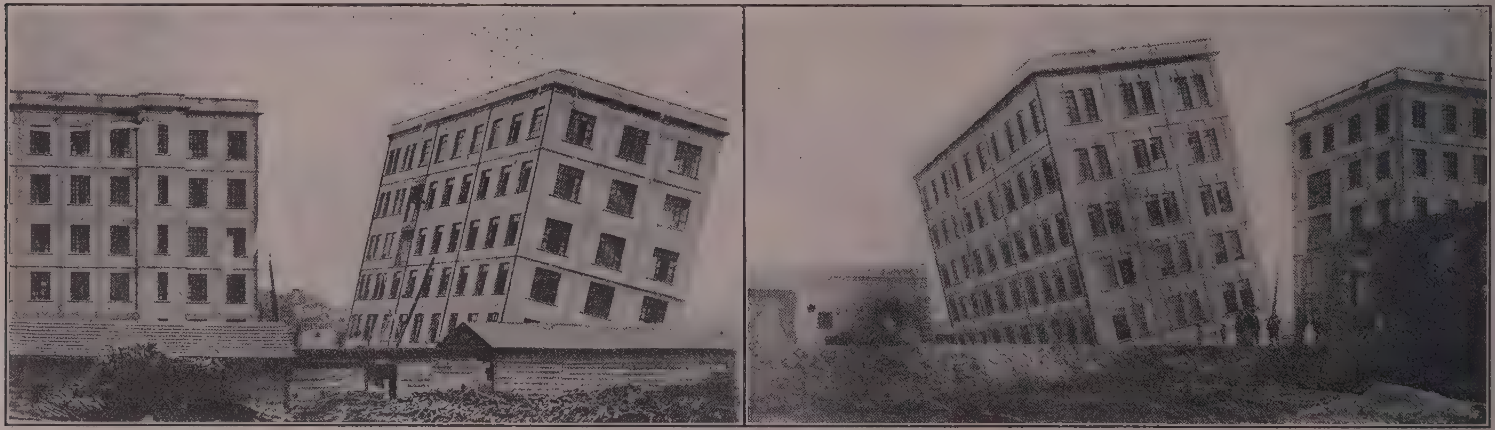
A recent example, however, on this marshy ground, far exceeding in magnitude and importance any of the numerous previous instances, and which offered for a few days a modern analogue to the well-known leaning towers of Pisa, or of Saragossa, deserves record. The Societe des Minoteries Tunisiennes has had in construction for many months past, three large buildings for the storage of wheat and flour, which Tunis now, as Carthage aforetime, ships in abundance to Europe. A central and two lateral blocks, the latter separated from the central one by some little distance. One of the latter was observed to be gradually deviating from the perpendicular towards the central block, without, however, losing its rigidity, and this movement continued en masse for several hours until an angle about 25 deg. was attained. The mass gradually displaced itself as a whole, a monolith, as it were, but the fall of the block was pronounced on all hands imminent. The engineer and contractor, however, took heart of grace, and, confident in the cohesion of the reinforced concrete, set about restoring the immense mass to the vertical.

This was duly effected in less than a fortnight. The floors on the elevated side of the building were weighted. This counterpoise consisted of some 2,000 tons of sand in sacks on the ground or basement floors, and 2,000 tons on the upper stories. Excavations were also made alongside the foundations on the high side so as to allow of the soil giving way more easily. The result was all that could be desired under the circumstances. The edifice returned to the vertical in a few days, and was then completed.

The work of the buildings proceeded during the summer as if nothing had happened until Aug. 28, which brought another disagreeable surprise to those interested in this important enterprise. It should be explained that the blocks were situated respecting each other like the strokes in the letter H. One of the end buildings started to lean from the perpendicular in June, and the other outside one on Aug. 28. The central one remained steady, possibly owing to the compression of the ground beneath and around it by the weight of the two side blocks. A few days previous to the last named date, one of the outer buildings being finished, the engineers resolved to load it with 3,000 tons ballast for the purpose of testing its stability and particularly letting it settle definitely. The first and ground stories had been loaded to the extent of about 1,500 tons, and this operation was still going on when the theodolite indicated a slight movement on the side furthest from the center block. The indications continued as follows: 7 a. m., 1 in.; 2 p. m., 3 ft.; 6 p. m., 9 ft.; 7 p. m., 9 ft. 11 in.; 9 p. m., 14 ft.; midnight, 17 ft.

It seems ascertained that the center of gravity around which as a pivot the building oscillated was a line passing through the center of the block. The floor of the building on the upheaved side, was elevated about 9 ft. above its normal height. The efforts of the engineer were accordingly directed to maintain this pivot of movement stationary and the methods adopted in June were also employed in August and with equal success, the material already in the building being transferred to the elevated side.

In the case of both buildings the settlement has been very considerable, for both now stand some 15 or 18 ft. below their intended level. The site is, of course, in the last resort responsible for these accidents, which have been a source of no little expense, delay and vexations. The ground, however, was declared sufficiently solid by the engineer whose plans were followed. The displaced and replaced buildings remain whole and their parts undisturbed, a wonderful testimony to the cohesion and tenacity of these concrete structures. The reinforced concrete is, of course, in consequence lauded to the skies, but there are those who maintain that in such situations the better course would be, at whatever expense, to adopt the American system of building upon a foundation of piles.



Two Views of a Reinforced Concrete Warehouse at Tunis which Tipped Sideways Owing to Poor Foundations.

The Recovery of a Broken Well Drill Point has recently been accomplished in a well 540 ft. deep at the Philadelphia Mint. The tool, 18 in. in length and weighing 19 lb., had lodged crossways at the bottom of the hole, and after it had been fished for unsuccessfully for 10 days, the well was about to be abandoned, when an electromagnet was tried which at once recovered the tool and all metal particles in the hole. The magnet was constructed of a 3-in. steel shaft, upon which was wound a 7-in. spool of No. 18 magnet wire, 9½ in. long, designed for a 220-volt current.

Tests of Other Woods Than Pine for Paving Purposes.

A paper read before the American Society of Municipal Improvements by F. A. Kummer, M. Am. Soc. C. E.

The increase in the price of long leaf yellow pine since the year 1900, at which time the company with which I am connected first began its purchase for paving block purposes, has been quite 50 per cent. I remember distinctly buying five and six years ago large orders of one million feet or more of all heart, long leaf, Georgia pine at considerably less than $20.00 per M. delivered at New York, while inferior grades of lumber to-day command a price of about $30.00 per M. It will readily be seen that a difference of $10.00 per thousand feet adds 36 cents per square yard to the cost of 4-in. block. Wood pavement being already the most expensive pavement in the market, at least so far as first cost is concerned, this heavy increase naturally to some extent has limited the market for this character of pavement. Not only has this been true so far as price is concerned, but the quality of the lumber obtainable has also decreased. Five and six years ago the material which we purchased for paving block purposes was cut from the best part of the tree and was dense, solid lumber, usually from trees of fairly large size. The lumber we get to-day contains a small proportion of sap wood, which is undesirable, and is usually cut from the tops and smaller parts of the tree and from smaller trees; and for this and other reasons is less dense in quality and requires more care and expense in treatment to bring it up to the standard which is called for by the best specifications. Appreciating these conditions, not only individual manufacturers of wood block, but the Bureau of Forestry of the Department of Agriculture have been conducting tests to determine what other woods of those available in this country can be successfully used for paving block purposes. The first test of this character of any size was arranged between three parties, viz.: The Department of Agriculture, The Kettle River Quarries Co., of Minneapolis, who are manufacturers of wood block, and the City of Minneapolis. Without going into the exact details of this test it has been arranged to lay a section of pavement in Minneapolis upon which the several kinds of wood are to be tested in comparison. Among these are Norway pine, which has been extensively used in that part of the country for street paving work, and tamarack, which has had a much less extensive use for this purpose but promises excellent results. This test, which is to be made on a heavily traveled street, should show much both as to the quality of these woods and the best methods of laying them, as in the test different forms of construction will be used. The writer does not feel at liberty, however, to go into a description of these tests at any greater length, as in advance of the results which the parties at interest may have to give out it would not be proper to do so.

View of Building in Tunis after Restoration to a Vertical Position.

Early this year the same arrangement was suggested by the Department of Agriculture, Bureau of Forestry, with the U. S. Wood Preserving Co. and the City of New York, the purpose being to test against long leaf yellow pine not only short leaf pine, but tupolo, loblolly pine, maple, sap gum, scrub pine and scrub oak. This test was to be somewhat similar to that made in Minneapolis, although embracing different varieties of wood and a different arrangement of the variables which could affect the construction; such, for instance, as the question of laying blocks on sand cushions or mortar bed; the best form of joints to be used between them, and whether the blocks give better results laid straight across the street or laid at an angle with the curb. The arrangements for this test have not yet been perfected, although this is not in any way the fault of the City of New York or the Department of Agriculture, but is due to delay on the part of the wood block company, who are not yet quite ready to undertake the experiment as proposed, pending other tests which are now being made. The writer has some doubts as to the value of tests on scrub oak, maple and some of the other woods named, as it is questionable whether they could be secured in large quantities, commercially, at reasonable prices, although in this respect there seems to be a confliction of opinion.

There is one wood, however, with which we have made some extended experiments in New York City with very satisfactory results. This is what is known in the South as black gum. The source from which we are now obtaining it is Norfolk, Va., and vicinity, but it no doubt exists in other localities in large quantities. Unlike red gum, it has not been particularly valuable for any general use, owing to its very irregular and crooked grain and the difficulty of properly seasoning it. One city block between the tracks of the Metropolitan Street Ry. on Hudson St., New York, was laid with this pavement about a year ago. The joints between the blocks were filled with paving pitch. They were laid on a cement mortar bed on concrete, as usual. They have given perfect satisfaction in every respect, have shown no tendency to swell and have worn, if anything, even better than the pine in the adjoining track. This wood, which is materially cheaper than pine and promises to remain so, possesses some advantages as a paving material and some disadvantages. Among its advantages may be named its extremely tough and close grain, making it not only a very durable block, but also one which does not split readily. This is an enormous advantage to the manufacturer, as waste in cutting, handling and shipping pine blocks is extremely large. Among its disadvantages may be named its greater weight in shipping, the greater length of time required to prepare it for treatment by driving off the contained moisture, and the fact that when this moisture is driven off the blocks require a greater amount of preservative per cubic foot to thoroughly impregnate them and fill up all the pores.

This wood is now allowed in the specifications of the Boroughs of the Bronx and Queens in the City of New York, as an alternate for pine, and the U. S. Wood Preserving Co. has recently taken the contract to lay a street containing somewhat over 60,000 sq. yd. with this wood in the Borough of the Bronx. Large shipments have also been made to Bridgeport, Conn., to Holyoke, Mass., to Springfield, Mass., for the main street there, and to Boston for the Boston Elevated Ry. for track work on Beacon St. Lexington Ave., New York City, from 42nd to 72nd St., between the tracks of the Metropolitan Street Ry. has also just been paved with this material, and 16,000 sq. yd. are now being shipped to Boston for street work. A contract has also been let to lay this wood on Green St. in Baltimore, Md. The specifications of the City of Cincinnati also permit the use of this wood as an alternative of pine, as do also those of a number of other places which I will not now mention. The writer enumerates these examples of the use of black gum to show the very large extent to which this wood is now being used.

In any determination as to the value of a wood for paving purposes, if we start with the assumption that by filling the pores of the wood throughout the block completely with a good quality of creasote oil decay can be prevented, there remains only one other question to be decided and that is whether the wood is sufficiently dense, tough and hard to successfully resist heavy travel. Such a determination is not a very difficult matter. In fact, it is almost self-evident that using Georgia pine as a standard, any block which is as hard or harder than this wood should give equally as good or better results, while those blocks which are not so hard, such for instance, as short leaf, loblolly and Norway pine, should give less satisfactory results. The writer believes that all these woods can be used for paving purposes if properly treated, but should be used with discrimination. A street laid with loblolly pine under moderate travel might readily give a serviceable life of twenty years or more, while a similar pavement under the excessively heavy travel found on such streets as exist in the lower part of New York City would probably be destroyed very quickly. The length of life of a wood block pavement is not directly proportional to the travel. Take, for instance, two streets laid with the same wood, in the same manner. If the traffic on one street approaches but does not reach the limit of durability of the wood, the pavement will last almost indefienitely because the character of the traffic is not sufficiently heavy to destroy it; but if the traffic, in its character as well as amount, passes the limit of durability of the wood employed, the pavement will be destroyed in a comparatively short time. It would seem that for each class of timber there is a condition of traffic beyond which it should not be subjected, but no determination of these limits could correctly be made except from a great number of actual service tests. In a general way, however, satisfactory results may be obtained by dividing the streets into three classes, heavy, medium and light travel. On the third class of streets practically any wood which would not decay would give an indefinite life. On the second class discrimination should be used, although woods as soft as Norway pine have given excellent results under these conditions. On the first class of streets it would probably be dangerous to lay any wood less durable and resisting than the best quality of long leaf pine. So far, the writer does not know of any available wood other than the black gum before mentioned which could be safely included with long leaf pine in this category. By this, of course, is meant woods which can be obtained in large quantities commercially, and which possess the element of toughness rather than that of extreme hardness.

While in Havana last July the writer saw a street, San Rafael St., beautifully laid with native hard woods, mostly mahogany, untreated. The surface of this pavement was almost as smooth as glass and excessively slippery, so much so, inded, that large areas of other streets in the city paved with the same material have been gone over by workmen with small chisels, who have cut the surface of the pavement into a sort of checker board of grooves so as to permit horses to safely travel over it. A somewhat similar although not so extreme condition has existed on many streets in London laid with Australian hard woods, and the slipperiness of these woods has been the reason why they have so largely been laid with a wide joint between the blocks, this joint being filled with pitch and crushed stone or gravel so as to give horses a foothold. The result of laying pavements in this manner is soon to give a rounded or cobble stone effect, due to the edges of the block wearing off, thereby destroying one of the chief advantages of a wood block pavement. The practive of laying blocks with a tight joint is increasing in London as the use of the Australian hard woods is decreasing. It will thus be seen that the element of toughness and durability in a block is not the same thing as extreme hardness of the wood. Beyond a certain limit many woods are too hard to make a successful paving material.

Among the woods listed for the proposed test by the Department of Agriculture in New York, above referred to, it seems improbable that there will be found any woods possessing the advantages of either long leaf pine or black gum for paving material. The scrub oak, if it existed in large quantities, might make a very durable wood but for the fact that oak. owing to its great tendency to split when subjected to heat, is a very difficult wood to treat. Maple, the writer is inclined to believe, would prove slippery, and Virginia pine, loblolly pine, short leaf pine and the other inferior grades of pine would not make block suitable for the heaviest travel.

The writer recently tested a number of South American woods, some of them so dense that their absorption under the usual time of treatment was only 4 lb. of creosote oil to the cubic foot, running down to others which absorbed 40 lb.. Some of these woods may prove useful for paving block purposes, but the great difficulty would be in separating the different kinds of wood. The tropical forests contain from twenty to twenty-five different kinds of woods, indiscriminately throughout the forest and not in large bodies of any one kind of wood. In getting them out these forests can only be successfully operated by taking out everything, thereby clearing the land for agricultural purposes, and with fifteen or twenty kinds of wood which may be valuable for paving block purposes, the manufacturer would be obliged to separate these woods into several different classes having approximately the same toughness and durability, as otherwise the pavement would naturally wear very unevenly. The writer believes, however, that from this source some very excellent materials can be obtained for street paving purposes. A large enterprise is now under way to get out lumber of this character in the United States of Colombia, and some of it should be on the market in the course of another year.

The Douglas fir or Oregon pine of the Northwest is almost an ideal material for general paving block purposes. It is not quite so hard or tough as long leaf yellow pine or black gum, and for this reason will probably be excluded from streets of the most extreme travel; but with the exception of perhaps a very few streets of this character it would prove equally satisfactory, and possess the great advantage of being extremely regular and homogeneous in texture, so that the differences between hard and soft wood found in the smaller long leaf yellow pine trees would not exist and pavements could be laid which would wear with perfect regularity throughout their entire surface. There is no opportunity [illegible] secure this wood for paving purposes east of the Mississippi River at the present time, but with the completion of the Panama Canal [illegible] will no doubt become a very extensively used wood for all purposes in the eastern part of the United States.

Quite recently another wood has been suggested for paving purposes of which the writer has very little knowledge, either as to its physical properties or its availability. This wood is chestnut oak, which is found in western North Carolina, eastern Tennessee and Kentucky and northern Alabama. It resembles oak, but is softer and less rigid of grain. No experiments have been made with it, but it promises to make a good wood for paving block purposes if it can be had in large quantities at a reasonable price.

Recently the writer had a talk with Mr. B. T. Fendall, city engineer of Baltimore, Md., who has just returned from a trip of several months through England and the Continent, inspecting foreign methods of paving. Mr. Fendall stated that he had nowhere in his travels seen as good wood pavements as those now laid in the city of Baltimore. This he attributes, first, to the fact that the woods used, Norway and Swedish deal, Pyrenees pine and native French pines, are softer than the long leaf yellow pine used in this country, and also to the fact that the blocks are not so thoroughly treated, only 10 lb. of oil to the cubic foot being used as against our 20 or 22 lb.

Mr. Fendall also exploded some of the prevailing notions about foreign pavements, notions which are very common and widespread in this country. One of these is the idea that the English or Continental engineers use extremely heavy concrete foundations under their pavements. This is not true. The heaviest concrete that Mr. Fendall found anywhere abroad was 7½ in. in Germany, and the usual practice is 6 in., generally gravel concrete. Most of these streets have been paved with macadam for many years and consequently when the sub-foundation is cut through the macadam sub-base looks like concrete and gives a wrong impression to the layman. Any engineer would know that foundations 12 or 14 in. thick, on ordinary well compacted sub-grades, would be only a waste of material.

Another point which impressed Mr. Fendall forcibly was the question of repairs. It has been stated time and time again that the foreign streets are so well kept up that repairs are always made with extreme promptness. Mr. Fendall did not find this the case and cited several of the principal streets in Paris with many bad places in them and in need of repairs. He attributes these holes to the use of woods not homogeneous in character and to imperfect treatment which allows some blocks to develop heart rot and quickly affect the surrounding pavement. This action of traffic on streets is one which affects largely the class of timber which can be utilized for street paving work. The writer has found from long experience that streets laid with blocks, some of which are hard and some soft, will wear very badly while the same street laid with all soft blocks would wear very well. This is due to the well-known way in which one soft block will affect its neighbors, the wear extending from one spot like a disease. The most perfect example of this that the writer has seen was in Havana this summer. The United States Wood Preserving Co., some five or six years ago, furnished to the Highway Department of the City of Havana several hundred yards of yellow pine block for a test on one of the heaviest traveled streets in that city. These blocks were of the old size, 4 x 4 x 8 in., and in laying them careless workmen sometimes put them down with the grain horizontal instead of vertical. The street in question has a very heavy travel of two-wheeled carts carrying heavy loads. Six blocks were laid in this street the wrong way. At the end of some five years there are six shallow depressions in this street some 24 in. in diameter and perhaps 2½ to 3 in. deep, perfectly regular and having at the bottom of each, in the exact center, a block laid the wrong way. With the exception of these six holes the street is in perfect condition. This shows clearly the way in which a soft block or a block wearing more rapidly than the surrounding blocks will infect, as one might say, its neighbors.

There is a general, although erroneous, idea widespread in this country that abroad the bulk of the paving is done with Australian hard woods. This is by no means true. The use of these woods is decreasing abroad. The English engineers have almost given up the use of the karri wood, although jarrah is still employed to a considerable extent. It is laid untreated, with an open joint to prevent slipping, as above stated.

On the Continent, especially in Germany, tallow wood is liked better than either of the others, but none of the three are in great favor. Mr. Fendall learned in Germany that the German engineers use large quantities of wood laid with close joints, on grades, because this pavement is less slippery than asphalt. It is fair to say that the asphalt employed is rock asphalt.

So far as our experience has gone it seems true that the best woods for paving block purposes are those which are dense and homogeneous, with little, if any, difference between the durability of different parts of the block, tough rather than hard, and capable of treatment without danger of warping or splitting. In addition, from a commercial standpoint, it should be necessary that such woods are obtainable in large quantities at reasonable prices. At this time it is safe to name four, in the order named: long leaf yellow pine, black gum, Oregon pine, Norway pine. Beyond these it is not certain what the results may be, although short leaf pine and tamarack have both been used in limited quantities, and the writer sees no reason why they should not be successfully employed if used on suitable streets. The question is one upon which continued experiment will throw more and more light as more tests are made and more results tabulated. To draw general conclusions from insufficient evidence is as useless in this as in any other subject.

Fires Caused Electrically during the last three months were 74 in number and resulted in $161,000 loss, according to a report of the National Board of Fire Underwriters. Eight were due to the crossing of high-tension wires with telephone and lighting circuits, nine were due to the grounding of lighting and motor circuits, and thirty-one were due to short circuits on interior wiring.

The Sale of Electric Power.

Although a number of articles on the sale of electric power have appeared from time to time, the subject is so far from being exhausted that many purchasers of current as well as central station managers will find much to interest them in a paper on the sale of large amounts of power read before the last convention of the New York Street Railway Association by Mr. S. B. Storer, general manager of the Niagara, Lockport & Ontario Power Co. Like all classes of public service in their early stages, this one started with a flat rate, which was soon found to be impractical for most cases. The ampere-hour meter, followed by various types of integrating and recording wattmeters, soon brought into use the idea of paying the exact amount of energy used, at a given price per ampere-hour or per kilowatt-hour. This method is still in very general use in its simplest form, but there has been dissatisfaction with it from the time it started. Neither the straight flat rate nor the straight kilowatt-hour rate is equitable, in Mr. Storer's opinion, except when applied in connection with a definite load factor—and even then it may not be entirely so, due to uncertainty as to the number of hours per day that full-load conditions prevail, with corresponding high efficiency, and to the hours during which operation continues at light loads with resultant low efficiency.

It is fully recognized now that the load factor is the root of the trouble, and unless a system of charging gives due consideration to it there will always be inequality of rates and dissatisfaction on the part of the power company or of its customers, or of both. Nor are power companies the only ones so affected by the load factor. No manufacturing company is entirely successful in the ordinary sense of the word unless it keeps all of its tools and equipment in use all of the time. No railroad can earn its full quota until it finds its tracks carrying their maximum number of trains every 24 hours and every train carrying fully loaded cars throughout. On every investment the interest, tax, insurance and depreciation charge—commonly referred to as the fixed charge—continues at a uniform rate over 24 hours of every day in the year, and unless the apparatus or material representing that investment is put to its maximum use every hour in the day and every day in the year there is an opportunity for increase in efficiency until the theoretically possible condition of maximum use is reached. The ratio of the use actually obtained to that theoretical or possible maximum use is the load factor of the manufacturing establishment and of the railway line, just as it is of the power house or transmission system.

Before taking up the question of rate-making and methods of charging, Mr. Storer referred to the cost of production of power from hydro-electric plants and from steam plants. In the former the cost is almost solely one of fixed charge, while the latter is made up from fixed charge coupled with variable items of coal, water, oil, waste and incidentals. With the hydro-electric plant, consequently, the cost per horse-power per year is almost constant regardless of whether supplied one hour per day or twenty-four hours per day. Repairs are about the only variable, and they may be considered as increasing in direct proportion to the load factor. Labor, oil, waste, etc., are nearly the same irrespective of the proportion of light loads to full load. With the steam plant, on the contrary, the items of coal, labor, etc., increase rapidly with the load factor, and hence the cost per horse-power per year increases in almost the same proportion.

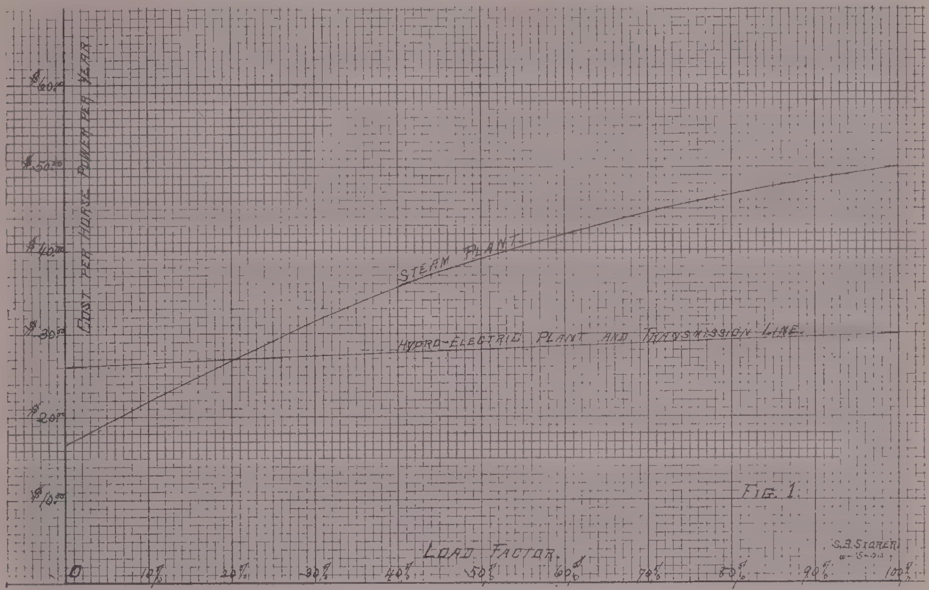


Fig. 1. Costs per Horse Power per Year in Terms of Load Factor, and Price per Horse Power.

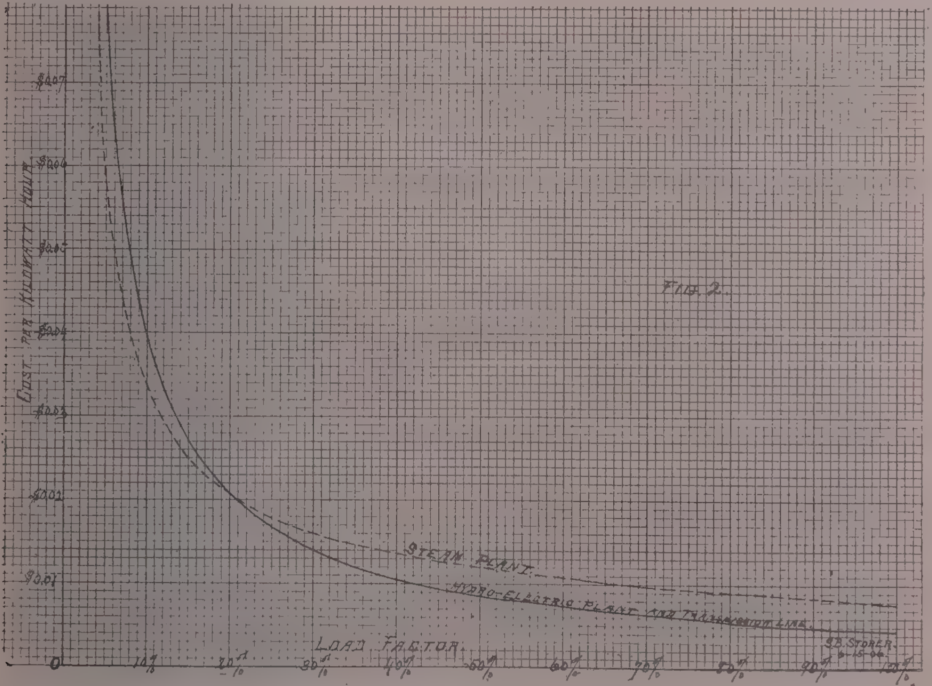


Fig. 2. Costs per Horse Power per Year, in Terms of Load Factor, and Price per Kilowatt-Hour.

The costs per horse-power per year may be shown graphically, as in Fig. 1, the curves being plotted in terms of load factor and price per horse-power per year. The curve marked "Hydro-Electric" is intended to represent cost of power after transmission for some distance, while that marked "Steam Plant" represents cost at the power house switchboard. These curves are about the best obtainable from any power houses of 5,000 to 10,000 h.-p. capacity with coal from $2.50 to $2.75 per ton.

In Fig. 2 the same costs are shown, but plotted in terms of load factor and price per kilowatt-hour. Particular notice should be given to the wide variation in cost per kilowatt-hour, it ranging in the steam plant from 9 cents at a load factor of 4 per cent. to about three-quarters of a cent at 100 per cent. load factor. The hydro-electric plant varies under the same range of load factors, from 10 cents to less than half a cent per kilowatt-hour.

In Fig. 3 is given a method of changing cost per horse-power per year at various load factors to equivalent cost per kilowatt-hour or vice-versa. The method to be followed in making the change is self-evident, so no explanation of it is needed.

The case of a hydro-electric plant and transmission system with a wholesale cost of $30 per horse-power per year was next taken up by Mr. Storer for the purpose of making, if practicable, a flat rate to consumers. He shows that there is little demand for power, as nearly every consumer has an intermittent load, or, in other words, a low load-factor, and cannot afford to pay or will not pay the price it is necessary to ask for flat rate twenty-four-hour power. It then becomes incumbent on the power company to devise a system of charging that will not only enable it to market its output, but to do so at prices that will secure a net revenue for the power equal to $30 per horse-power-year, besides an additional amount sufficient to cover the cost of retailing or distributing it, but to further enable it to sell at rates low enough to be attractive to consumers. Mr. Storer therefore proposed that everything should be sold on a maximum demand basis, with the rate per horse-power per year varying between fixed limits in accordance with the consumer's load-factor. In order that this method may be clearly understood, mention should be made of the fact that the load-factor is computed on the basis of a twenty-four-hour day; the kilowatt-hour consumption per day, divided by 24, being taken as the average demand, and dividing this average demand by the maximum demand for that day, a fraction—or in one case unity—is obtained representing the load-factor for the given twenty-four-hour period. In the same way the load-factor for any month may be obtained by dividing the average rate of consumption for the entire month by the average of the daily maximum demands, thus obtaining the average load-factor of all the days in the month.

The maximum demand is taken as being the highest rate of consumption for any one minute during the day; or, as it is perhaps more commonly expressed, the highest one-minute peak occurring during any day is considered as the maximum demand for that day. The average of these highest daily one-minute peaks occurring during any month then becomes the average maximum demand for that month and is so used in the calculation of load factor.

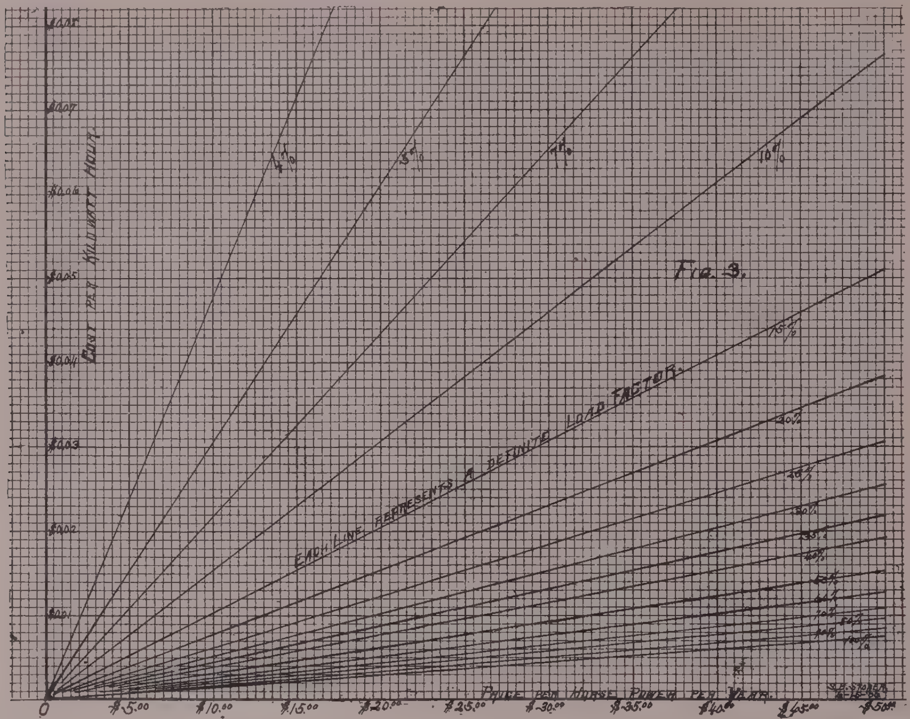


Fig. 3. Diagram for Changing Cost per Horse-Power per Year to Equivalent Cost per Kilowatt-Hour.

Assuming that a manufacturer has made a contract to buy 400 h.-p. for the operation of his factory, and that the rate per horse-power-year varies between the limits of $16 and $43, depending on the load factor, the determination of his rate per horse-power per year for any given month would be as follows:

If the kilowatt-hours consumed during a thirty-day month are 43,200, then the average demand for power is 43,200 divided by 720 (the number of hours in the month), equal to 60 kw. or 80 h.-p. Assuming further that his maximum demand each day was just 400 h.-p., then, of course, his average maximum demand for the month will be the same amount, and the load factor is 80 divided by 400 = 0.2, or, as commonly expressed, 20 per cent.

If the rate per horse-power year varies between $16 and $43, it will be evident that the variable quantity is the difference between $16 and $43, or $27. The rate is therefore equal to the minimum rate ($16) plus the load-factor (0.2) times the variable ($27). Two-tenths of $27 is $5.40, so the rate per horse-power per year for that month will be $16 plus $5.40 equals $21.40. The total charge for the month would therefore be 400 times $21.40 divided by 12, or $713.33. This is equal to 1.65 cents per kilowatt-hour. If his use of the power had been such as to give a load factor of 30 per cent., the rate per horse-power per year would have increased to $24.10, but the equivalent cost per kilowatt-hour would have decreased to 1.24 cents—a reduction of almost 25 per cent. in cost per kilowatt-hour due to increasing the load factor to 30 per cent.

This may readily be put in the form of an equation which, if the desired rate per horse-power per year is R, the minimum rate limit is A, the maximum rate limit is B, and the load-factor is L, is expressed by $R = A + L\ (B\text{-}A)$.

This method Mr. Storer considers much more equitable than that sometimes used, of selling all the power on a kilowatt-hour basis with a guarantee from the consumer of a specified load-factor. By referring to Fig. 4, there will be seen the diagrammatic equivalent of such a method of charging converted into a cost per horse-power per year basis. The example given there is that of a kilowatt-hour cost of one cent with a guaranteed load-factor of 30 per cent. This simply means that the consumer pays a flat rate per horse-power per year of $19.60 at all points from zero load-factor to 30 per cent. load-factor inclusive, and from 30 per cent. to 100 per cent. load-factor the rate increases in direct proportion until it reaches the limit at $65.35 per horse-power per year at 100 per cent. load-factor.

This method is bad for both parties to a contract, Mr. Storer stated. For the power company, if we assume that any considerable transmission is involved, and that a relatively large amount of power is under contract to be delivered, the price of $19.60 per horse-power per year is too low to cover cost—much less than necessary to pay a profit. There is also no probability that the rate will ever be much higher than this, as there is no inducement to the consumer to increase his load-factor above the guaranteed 30 per cent. On the other side, the consumer has a right to assume that the price at the guaranteed load-factor offers a fair return per horse-power per year to the power company, and consequently no effort is made to increase his load-factor, particularly as his cost per kilowatt-hour remains the same. If, however, the contract is one of long duration and, due to natural causes beyond control of the consumer, the load-factor should increase to a high value, say 75 or 80 per cent., the consumer would be paying over $50 per horse-power per year for power that he is justified in thinking does not cost over $20 or $25.

A better way of charging, in Mr. Storer's opinion, would be to sell the power on a maximum demand basis with the rate varying between the limits of say $18 and $38 per horse-power year—this rate-line also being shown in Fig. 4. With this way of charging there is a continual inducement held out to the consumer to increase his load-factor. The power company would probably also increase its profits somewhat by the increase in load-factor, but only to a comparatively small extent.

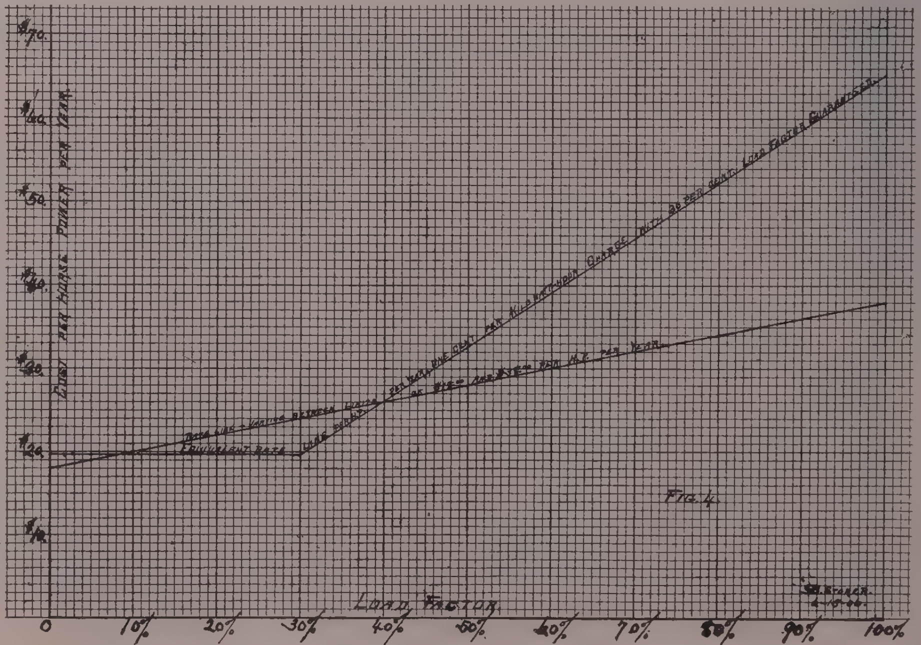


Fig. 4. Suggested Plan of Charging for Electric Power.

In Fig. 5, Mr. Storer gave the two curves of load-factor and cost per kilowatt-hour in order to indicate more clearly than by words the advantage of the system having as its basis the load-factor of the consumer. The dotted line represents the one cent per kilowatt-hour rate with a guaranteed revenue equal to that from a 30 per cent. load-factor consumption; the full line or curve gives the equivalent cost per kilowatt-hour of the variable $18 to $38 per horse-power-per-year rate.

With such a system of charging established, the question immediately arising will be as to the manner in which the limiting values per horse-power per year are established, with power companies of different capacities to supply demands of all kinds and sizes.

Referring to the assumed case of a hydro-electric plant and transmission line wherein the wholesale cost is $30 per horse-power per year, and further assuming that the rated capacity of the system as a whole is 10,000 horse-power, Mr. Storer drew in Fig. 6 a vertical line from the zero point at the middle of the lower line, and laid off in price per horse-power per year. On the lower line to the left he laid off the amounts of power that may be sold, up to the capacity of the plant. To the right is laid off the load-factors that may be obtained by the various consumers. From the $30 point on the vertical line a horizontal line is drawn to the left that may be known as the "base-rate line."

If power is to be furnished to consumers having a load-factor of approximately 100 per cent. and sold on a straight flat rate per horse-power per year, then the cost of retailing the power in small amounts will increase the cost as the amounts decrease, approximately in accordance with the curve starting from the base-rate line on the 4,400-h.-p. point, and increasing to $43 on the zero horse-power line. If the consumer takes anything over 4,400 h.-p., he may be considered as being entitled to the wholesale rate of $30 per horse-power per year. If, however, the consumers operate at a low load-factor, the power company may "oversell" its plant to an extent directly dependent on the relation between the capacity of its plant and the amount of firm power sold to each one. The amount it may be oversold may be determined approximately from the equation of the "law of probability," or graphically from the "probability curve," both of which may be found in books on higher mathematics.

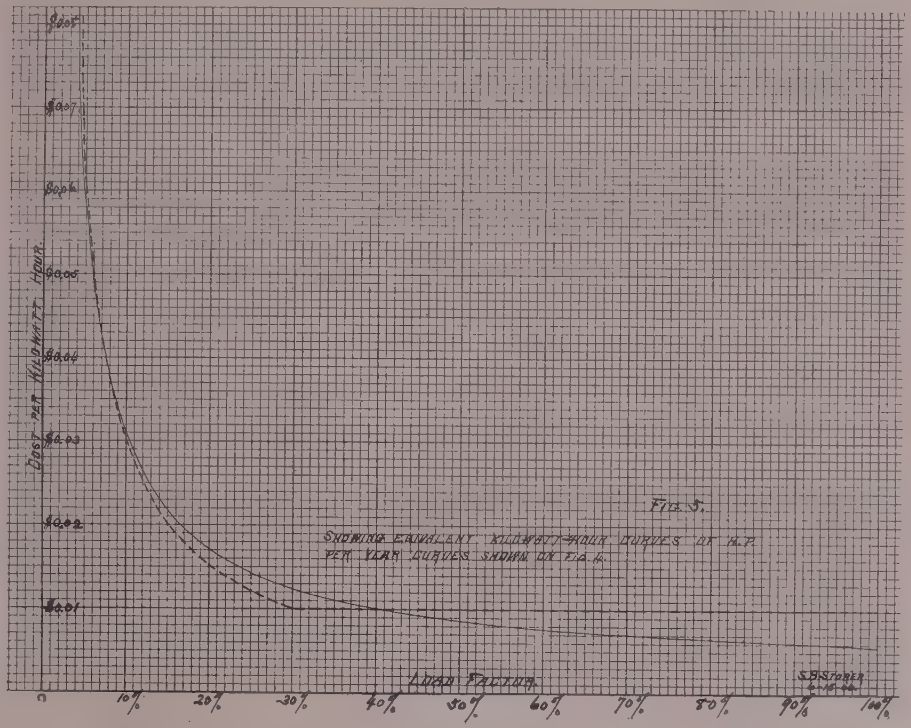


Fig. 5. Equivalent Kw-Hour Curves of Horse-Power per Year Curves in Fig. 4.

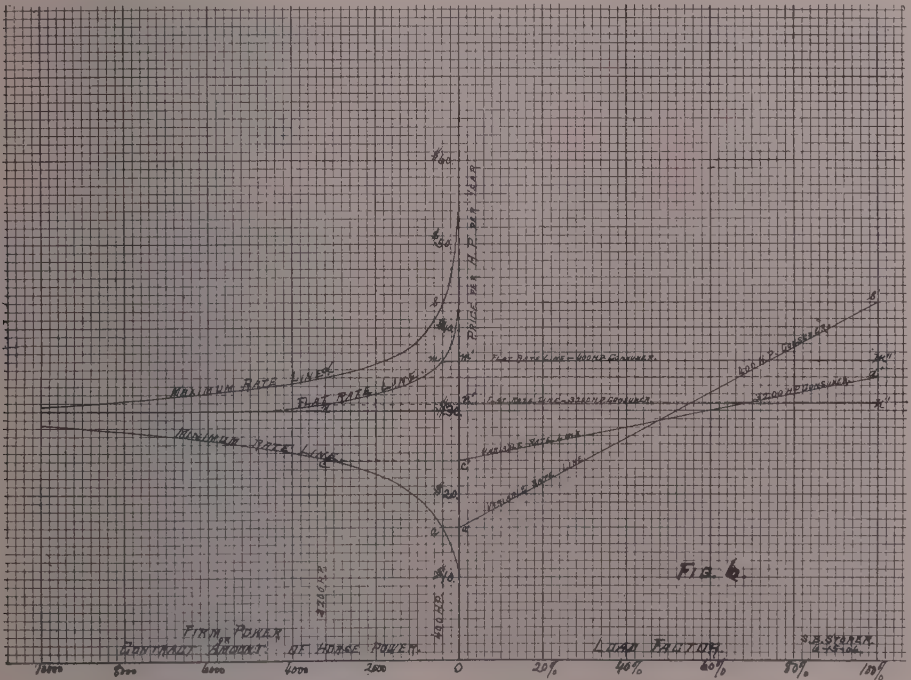


Fig. 6. Results Under Suggested Plan for Charging for Electric Power.

If a large number of motors are operating in a city, performing all classes of work, starting and stopping, running part of the time at full load and part of the time at light loads, the ordinary amount of power required to supply them will be much less than the total rated capacity of the motors, and still every one of the motors may at some time during the day have been operating at full rated load. As a matter of actual practice the ratio is about three to one, the motors, of course, being mostly of from ¼ h.-p. to 20 or 30 h.-p. The 10,000-h.-p. plant could therefore safely connect on its circuits small motors having a total rated capacity of 30,000 h.-p. The average load-factor of the different installations would not be much, if any, over 15 per cent., and where occasional large installations are operating somewhat more uniformly, the load-factor would reach perhaps 25 per cent., it being assumed, of course, that they are practically all ten-hour factories. To such factories, of say 400-h.-p. capacity, the power could not be oversold more than twice. If the entire output were sold to one, two, or even three large consumers, the plant could not be oversold at all, as the chance of both or all three of the consumers taking their maximum of power at the same time is so high as to become almost a certainty. With a single 10,000-h.-p. consumer there is no "chance" about it, and such a customer must pay the full flat rate of $30 per horse-power per year regardless of load-factor.

In Fig. 6, the curve marked "maximum rate line" is an approximation of the "probability curve," drawn with reference to the $30 base-rate line and the central vertical line. The curve marked "minimum rate line" is also an approximation of the "probability curve," drawn with reference to the same line, but on the lower side of the $30 base-rate line.

The minimum rate or the zero load-factor rate for any amount of power may be found by following the vertical line from the desired amount of power indicated by the figures at the bottom line of the diagram until it intersects the minimum rate line. From the point of intersection follow the horizontal line to the right of the vertical line at the middle of the diagram, thereby obtaining the amount in dollars per horse-power per year. In the same way, from the intersection of the vertical line indicating the horse-power with the maximum rate line, the amount of the maximum rate per horse-power per year is obtained.

Taking as an example a 400-h.-p. consumer, the intersections are found to be at *a* and *b* on the minimum and maximum rate lines, corresponding to $16 and $43, respectively. Carrying a horizontal line to the right from *b* to *b'* on the 100 per cent. vertical load factor line, and connecting *a'* and *b'*, there is obtained a variable rate line for 400-h.-p. consumers. The rate for consumers desiring to buy on a straight flat rate regardless of load-factor is obtained from the point *m* where the 400-h.-p. line crosses the flat-rate line, or at the $36 point. In the same way a 3,200-h.-p. consumer's variable rate would be from $24 to $34, with a corresponding flat rate of $30.40, and the variable rate line runs from point *c'* to *d'*.

Referring to the small consumers having a load-factor of approximately 15 per cent., and following the same method given above, ascertaining that the variable rate is from $11 to $52—at 15 per cent. load-factor, the rate would be $11 + .15 ($52 — $11) = $17.15.

In view of over-selling three times for this class of consumers, the gross income derived from each horse-power actually delivered from the plant would be three times $17.15, equaling $51.45, or practically the maximum rate. This increased return per horse-power output of the station, over the corresponding straight flat-rate price of $41 per horse-power year, is made necessary by the fact that three installations must be made to get the gross revenue of $51.45, while only one is required for the $41 revenue. The difference in revenue is therefore just about sufficient to make up for this additional expense.

In the same way, the 400-h.-p. consumer with a load-factor of 25 per cent. would pay at the rate of $22.75 per horse-power per year, and over-selling twice would bring in a gross revenue of $45.50 per horse-power per year.

The combination of these two rate curves, both approaching the $30 base rate line as the firm power increases, taken in conjunction with the method of charging that depends on the load-factor of the consumer, furnishes a system that affords, in Mr. Storer's opinion, absolute protection to the power company and at the same time gives all consumers every benefit of low price that can be done with safety to the vested interests of the power company. Each consumer would pay a rate per horse-power per year such as to give the power company a uniform percentage of profit on all its business, so there could be no question as to "preferential rates" and certain consumers having advantages over others.

It may be said that the maximum demand is hard to measure, but with a demand for that class of meters there will come an instrument capable of fulfilling the requirements. For the most part, in small installations, the maximum demand may be taken as the rated capacity of apparatus installed, and an ordinary integrating wattmeter giving the kilowatt-hour consumption per month, for use in determining the load-factor, is all that will be required. With large installations, where greater accuracy is required, more money may be spent on individual measuring instruments with no relative increase in cost of meters over that of the many small consumers, and the total error in records, Mr. Storer believed, would probably be very much less than under present service.

In the sale of power on the maximum-demand basis, the question of the amount of firm power to be taken, and the permissible demands above that amount, are always the subject of much discussion. In this system, however, intermittent demands in excess of the firm power may be permitted in percentages approximately those obtained by following about the same curve as the maximum rate curve—measurement being made from the $30 base line up to the curve. For example, the small consumer may be permitted to take power 100 per cent. above his firm amount; the 2,000-h.p. consumer, allowing for probable maximums occurring at the same time, would be entitled to about 25 per cent. intermittent demand. At the 10,000-h.p. limit, no intermittent demands could be permitted, as there is nothing with which to furnish them.

All permissible intermittent demands are paid for at the same rate per horse-power per year as the firm power, and are to be measured by the highest, daily, one-minute peaks, or average one-minute demands in excess of the firm power. The one-minute peak is taken for the reason that any load lasting for a full minute means a definite and corresponding opening of the gates controlling the water wheels, and therefore limits their output as much as if it lasted much longer.

It is not to be expected that this system of charging—based as it is on the "law of probability"—will apply where only one class of service is supplied, as, for example, incandescent lighting. There is very little "probability" about that service, for people want the light when it is dark and the demand consequently comes at that time. Where, however, lighting is only one of many other uses for power, the system indicated above applies with equal force and may be used for every consumer, regardless of size or of the use to which the electric energy is put, and also of the number of hours per day it is supplied.

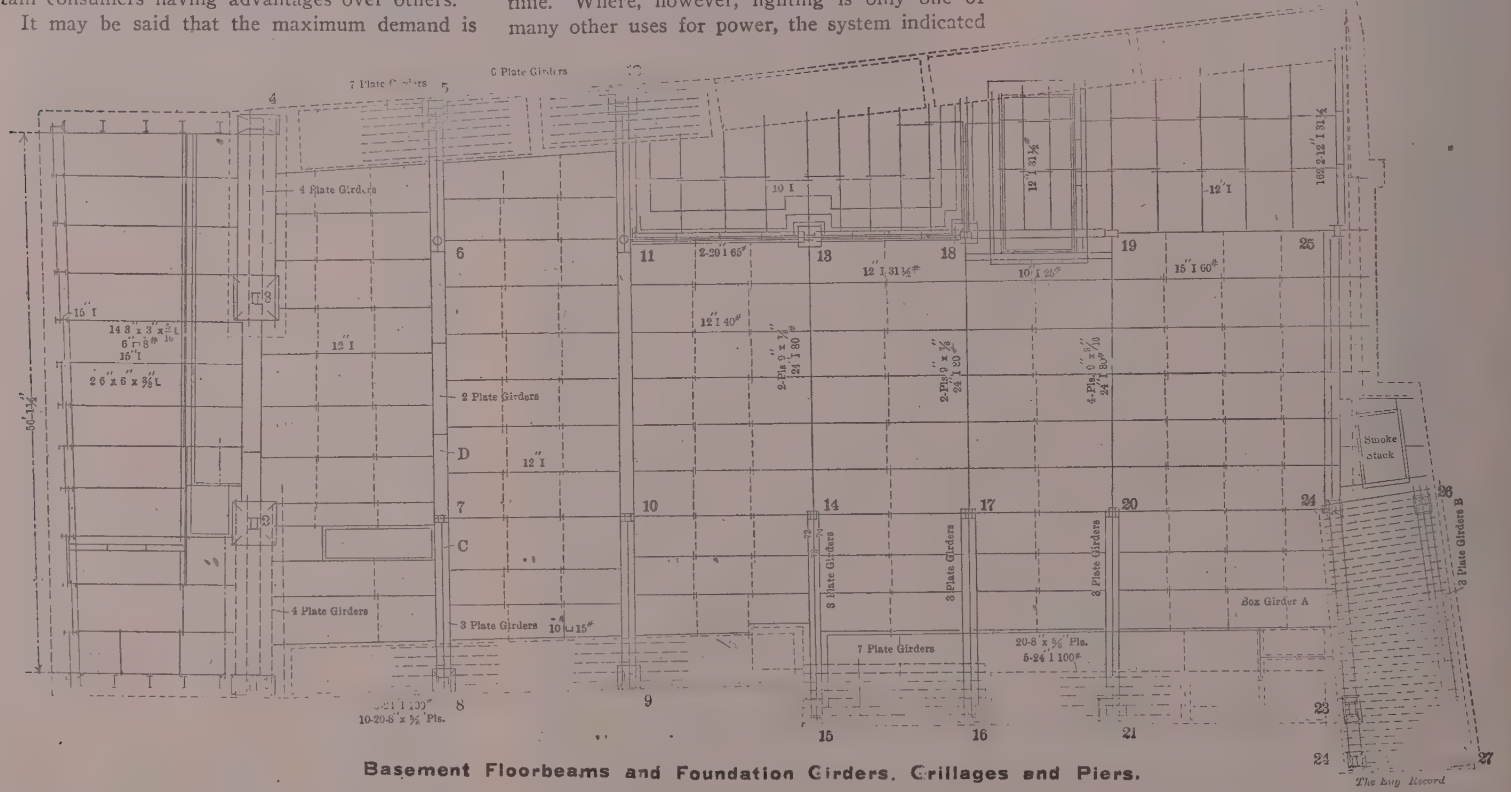
The same system may also be applied to steam plants if consideration is given to the range in cost due to change in load-factor. The modification would appear in Fig. 6 by using two base-rate lines, one at about $20 and the other one at about $55. The minimum and maximum rate curves would then be drawn with reference to these two lines, leaving a considerable variation in price per horse-power per year between zero and 100 per cent. load-factor even for the largest consumers. Greater leeway as to permissible intermittent demands could also be given, due to steam engines being capable of temporary overloads to a much greater extent than are water wheels.

The Trust Company of America Building, —III.

Foundation Girders.—The superstructure is carried by twenty-seven main columns in the walls and in one intermediate longitudinal row. On account of the irregularity of the lot and the architectural requirements, the arrangement of the columns is not symmetrical, the transverse spacing being very wide in the front part of the building and narrower in the rear. The wall columns are seated singly or in pairs on comparatively long and narrow rectanglar concrete piers which, as described in previous articles, form part of a continuous wall carried to rock and enclosing the entire lot. They serve as a retaining wall and watertight dam, excluding the ground-water, which is under considerable pressure at the lowest part of the excavation. At one rear corner the lot is extended by an irregular offset and five wall columns are supported on the same large pier.

The intermediate columns have separate rectangular piers from 7 to 9 ft. square and from 15 to 22 ft. apart on centers. There are only two interior columns in the front part of the building, where the excavation for the boiler room is carried down about 31 ft. below the curb. Adjacent to it on the inner side, the sub-basement floor is 7 ft. higher and is separated from it by a transverse retaining wall. On the opposite side of the boiler room the floor of the sidewalk coal vault is also about 7 ft. higher, but is separated from the boiler room by the wall piers. The three exterior sides of the coal vault are enclosed by vertical concrete walls about 2½ ft. thick, reinforced by 18-in. vertical I-beams 5 ft. apart on centers.

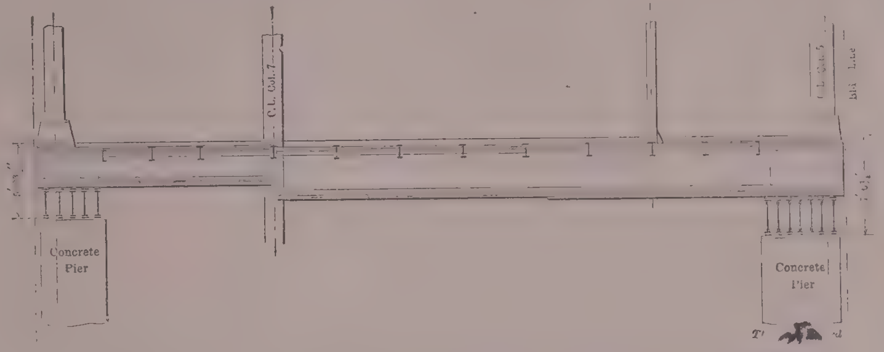
The intermediate piers are proportioned for the sectional area required to reduce the column loads to the permissible pressure of 30,000 lb. per square foot allowed on the concrete by the building law of New York City. Some of the loads are very heavy and being concentrated at the feet of the columns require special distribution to insure uniformity of pressure on the tops of the piers, which is attained by the use of extended pedestals and heavy single and double



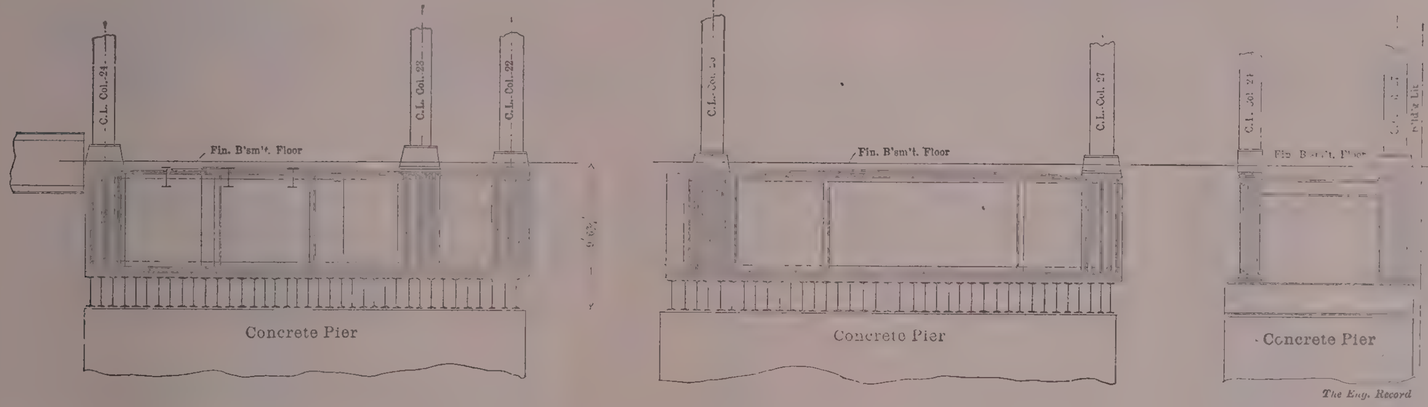
Basement Floorbeams and Foundation Girders, Grillages and Piers.

I-beam grillages and by the use of offset upper courses of cut granite which are allowed to sustain heavier pressures than the concrete. The wall piers are subject to smaller proportional stresses from the direct column loading, but as the columns they carry are in all cases unsymmetrical with their centers of gravity, it is necessary to provide grillages and girders with bearings arranged so as to apply their loads symmetrically with the centers of gravity and to distribute them uniformly over portions of the surface of the piers.

The columns are arranged as shown in the basement floor plan in transverse rows and in order to provide for the eccentricity between the wall columns and the wall caissons the columns in each row are united by transverse girders arranged to form cantilevers and connecting girders and to distribute the loads and reactions as required on the wall piers and on the intermediate piers, thus making the main foundation girders continuous across the full width of the building except in three intermediate lines in the rear of the building, where the columns in one wall are independent of all others. In the Wall St. front of the building the girders are parallel to the long sides of the piers supporting them and can therefore be seated directly on the concrete, their lower flanges providing sufficient distribution of the pressure on the masonry.

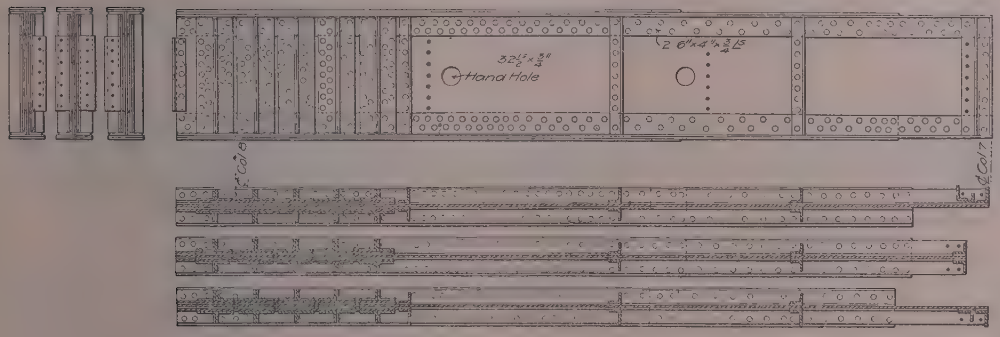


Triple Web Cantilever Girders Connected by Double-Web Girder.



Cantilever and Distribution Girders on Corner Pier.

In other cases the girders are transverse to the piers and take bearing on them through I-beam or girder grillages transverse to the main girders. These are designed to receive uniform loading throughout the length of their bearing with the main girders and to distribute it to the masonry over their whole horizontal projection. The center of application is therefore at the center of gravity of the grillage while the column loading is transferred from the center of the column through the center of its girder bearing, thus making a cantilever arrangement although the girders do not project beyond the outer edges of the grillages. The grillage beams and girders are calculated as double cantilevers and on account of their great depth are proportioned for unit stresses without regard to deflection. In the intermediate rows, the interior columns are seated on piers having their tops below the sub-basement floor while the wall columns are seated about 20 and 13 feet higher on the tops of the caissons in the boiler room and basement floor levels respectively. The cantilever girders which support the wall columns are therefore connected to the intermediate columns several feet above their bases, and the intermediate columns themselves are connected by center panels of girders at the basement floor level, which are virtually connected to the ends of the girders seated on the wall caissons and thus form a system of continuous girders reaching entirely across the building, developing continuous girder stresses in the whole system and utilizing the loads on the intermediate columns against the upward reactions developed by the cantilevers.



Cantilever Girder Connecting Columns 7 and 8.

Columns 22, 23, 24, 26 and 27 are carried on a special corner pier 13½ ft. wide and about 31 ft. long, with its angles slightly oblique to conform to the directions of the building lines. The top of this pier is entirely covered by twenty-eight transverse 24-in. 80-lb. I-beams set close together and secured by cast iron separators and tie bolts. Distributing girders are seated across the opposite ends of the grillage beams and carry the four corner columns and the intermediate column, distributing their loads uniformly over the grillage beams, and through them across the pier.

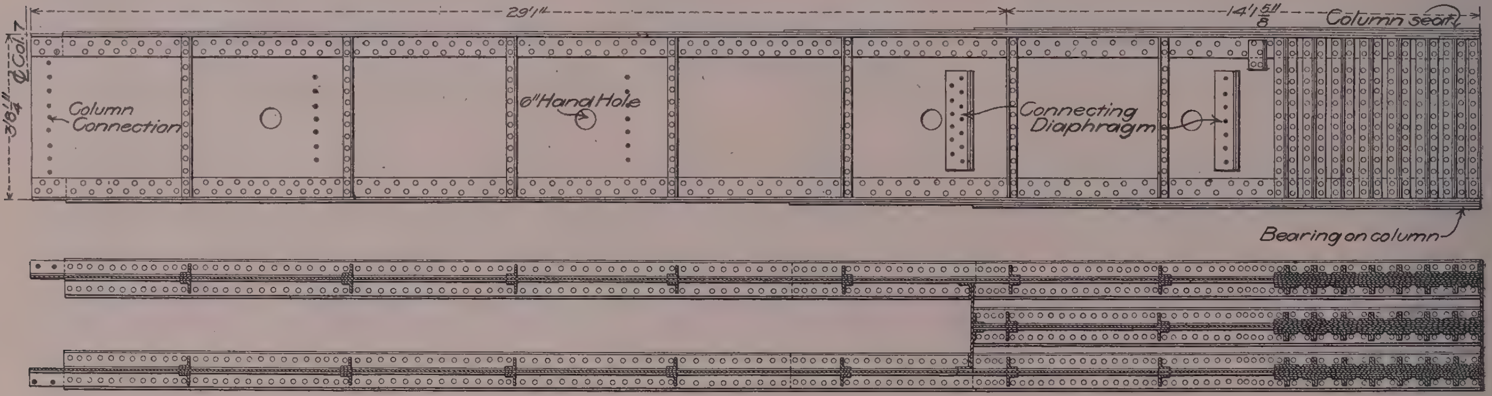
One of the distributing girders, *A*, carries three columns and is made as a single massive box girder having three 77½ x ¾-in. web plates, eight 6 x 4 x ⅞-in. flange angles and eight 20 x ¾-in. flange cover plates, six of them being full length. There are also four 9 x ½-in. full-length vertical flange plates. The webs are reinforced at the ends of the girders by eight 75½ x ½-in. plates riveted to both sides of the center web and to the outsides only of the outer webs. They are riveted over the vertical flanges of the flange angles and vertical flange plates, thus leaving ⅞-in. spaces between them which are closed on the vertical lines of the rivets with fillers, indicated by dotted lines in the elevation.

At the ends of the girder and at one intermediate point where the columns receive bearing, the girder webs are stiffened by pairs of angles, mostly 3½ x 2½-in., which transmit the shear directly from the top to the bottom flanges and virtually constitute short pillars, continuing the columns across the girders. This girder weighs about 31½ tons and will be riveted up complete at the shops. The corresponding girder, *B*, on the opposite side of the pier is made with three single girders delivered separately. Each of them has a 77½ x ¾-in. web reinforced by one 75½ x ⅜-in. plate at each end, four 6 x 4 x ⅞-in. flange angles and eight 9 x ¾-in. flange cover plates. Each of the three girders will be handled separately and will weigh about 11½ tons.

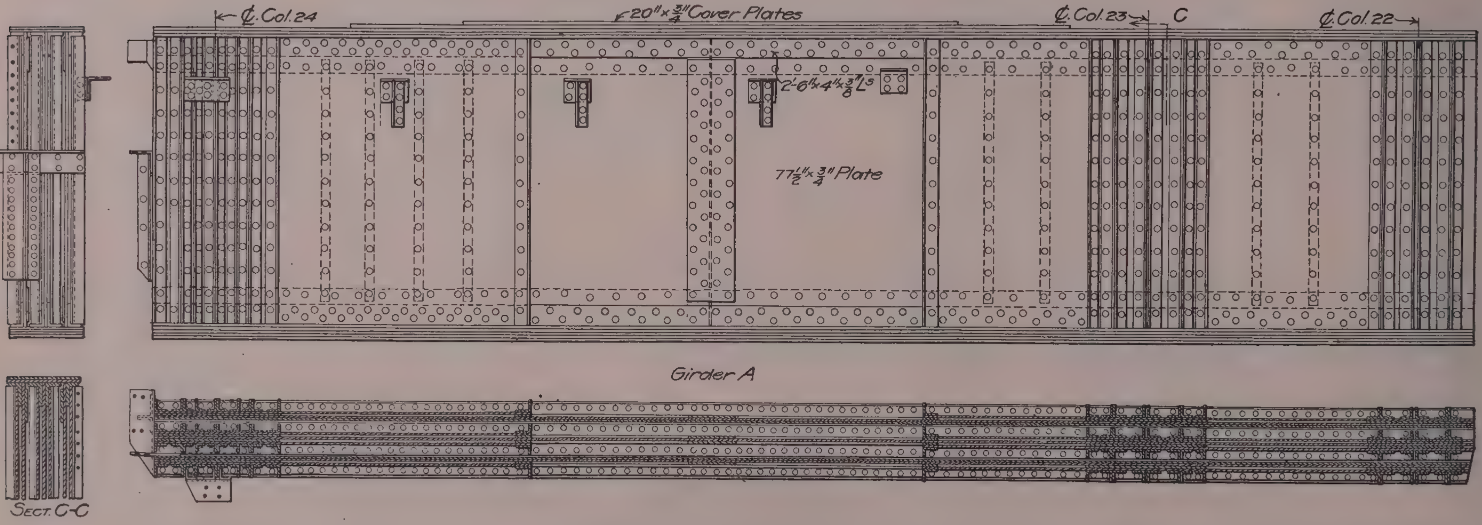
Columns 5, 6, 7 and 8 form a typical transverse row in the front part of the building and are supported by a system of connecting and cantilever girders like those for the adjacent row of columns 9, 10, 11 and 12. Wall columns 5 and 8 are set close to the party lines, eccentric with the wall piers, and are therefore carried on the projecting extremities of cantilever girders which have their fulcrums on the centers of gravity of grillages reducing the pressure on the concrete and distributing it uniformly and symmetically on the wall pier. The grillage for column 8 consists of five 24-in. I-beams 12 ft. 8 in. long, with each flange reinforced by two 8 x ⅝-in. cover plates.

Column 5 has a heavier load and its grillage consists of seven plate girders 16 ft. 8 in. long, each with a 23 x ¾-in. web plate, four 6 x 4 x ¾-in. flange angles and four 9 x 9/16-in. cover plates. Together they occupy the full width of the pier and distribute the 2,685,000-lb. load of the column over an area of about 100 sq. ft. The cantilever girders seated on these grillages support the wall columns on their upper flanges and at the other end are web-connected to the interior columns with their tops about 20 ft. above the bases of the latter, thus utilizing a portion of the loads to resist the upper reaction and to allow the remainder of it to be supported in the ordinary way by the interior piers at a lower level.

The cantilever girder, *C*, connecting columns 7 and 8 consists of three separate plate girders, each made with a 32½ x ¾-in. web plate, four 6 x 4 x ¾-in. flange angles and one full length and one part length 10 x ¾-in. cover plate on each flange. The outer ends of all the girders are in the same vertical longitudinal plane and are connected after erection by a vertical transverse plate, field-riveted across their end web-stiffener angles.



Details of Compound Girder D.



Details of Distributing Girder A.

The center girder, about 17½ ft. long over all, is web-connected at the opposite end to column 10, while the two outside girders have their flange angles cut on one side at this end so that their webs projecting beyond the end of the center girder are field-riveted to the cover plates of column 10. At the outer end each girder has the web stiffened by two 30½ x ⅜-in. cover plates 5 ft. long, riveted over the vertical legs of the flange angles, and by several pairs of 6 x 3½ x ⅜-in. vertical angles back to back, spaced close together and affording with the web plates a cross-section proportioned for the shear and massive enough to resist buckling. The three girders are connected by two sets of intermediate vertical transverse diaphragms having I-shaped cross-sections made of one plate and two pairs of angles and bolted to the girder webs, hand holes being left for that purpose adjacent to them at the outside webs.

The construction of the compound girder, D, reaching from column 5 to 7 is somewhat different from that just described and combines an end section similar to that of girder C, with a double-web connecting section from column 6 to 7, and made continuous with it. It has two outside girders about 43 ft. long, seated at one end on a grillage above which column 5 is carried on the top flanges, and at the opposite end their webs are field-riveted to the cover plates of column 7, where they abut against the ends of girder C. At the outer end a center girder 15 ft. long is set between the two long girders. The outer ends of all are in the same longitudinal plane and the inner end of the short girder is rigidly connected to the longer outside girders by a vertical transverse diaphragm, field-riveted to it and bolted to the webs of the long girders. The short center girder receives part of the load from column 6 and serves to reinforce the long girders and provide for the increased local stress at this point due to its function as a continuous girder.

All these girders are made with a 43¾ x ¾-in. web plate, four 6 x 4 x 1-in. flange angles and four 10 x ¾-in. cover plates. Over the grillages the webs are reinforced as in the case of girder C, by pairs of 41¾ x ⅜-in. plates about 6 ft. long and by pairs of 4 x 3 x ¾-in. vertical angles. Besides the full-length cover plates, the long girders have part length 10 x ¾-in. and 10 x ⅜-in. cover plates on each flange. The short girder has two 10 x ¾-in. plates and one 10 x ⅜-in. plate, all full length on each flange. Each long girder weighs about 18,500 lb. and the combined weight of the set of girders supporting columns 5, 6, 7, 8 is about 63,000 lb.

The rivets in the girders carrying columns are countersunk in the top flange, under the cast-iron bases, and in the bottom flange over the grillage. Rivets in the grillage girders are flattened in the bottom flanges and in the top flanges under the girders carrying the columns. The space left between the bottom flanges of the cantilever girders and the top flanges of the grillage beams is intended for grouting, to insure uniform bearing on the grillage beams.

Mr. Francis H. Kimball is the architect, and Messrs. Purdy & Henderson are the consulting engineers for the structural steel work, which is furnished by the Carnegie Steel Co.

(To be Continued.)

New Sewerage Plans for Louisville.

The new sewerage plans for Louisville, recently prepared by Mr. J. B. F. Breed, chief engineer of the Sewerage Commission, and Messrs. Samuel M. Gray and Harrison P. Eddy, consulting engineers, are in three forms, one of which is specially recommended. It provides for the remodeling of the present system and the construction of new district sewers, each discharging through an outfall sewer into the Ohio River. The opinion of the engineers consulted on the subject was that it would be many years before the city would be compelled to purify the sewage before it was discharged into that stream, but the plans have been so drawn that it will be practicable at any time to run a large intercepting sewer along the river front to carry the entire dry-weather sewage of the city to a point down the river where there is a suitable site for purification works. The plans call for combined sewers in most districts and for the improvement of some existing water courses to serve as storm-water channels. The estimated cost of the work is $4,000,000.

Adjustment of Bench Levels.

By Samuel D. Bleich, Assistant Engineer, New York Rapid Transit Railroad Commission.

In connection with the surveying work conducted by the Rapid Transit Railroad Commission, several level parties have been sent out from the Sewer Division under charge of Mr. Amos L. Schaeffer, division engineer, to establish bench marks along all the lines of the proposed subway routes. Several lines were run along the different avenues of Manhattan, and these were connected by cross-runs through many streets. As a result all these lines comprised many closed circuits. It became necessary to adjust the field work so as to obtain for all the benches elevations which would be geometrically consistent with one another.

The simplest method would be to consider each longitudinal line of levels separately. After obtaining average differences of elevations between successive benches or turning points of all the runs made along the line and beginning with an established elevation, it would be necessary to apply these averages with their proper signs in sequence to obtain the elevation of all the benches along this line. But on assigning elevations to the benches according to this method along several longitudinal lines, it frequently occurred that the elevations thus established would yield material differences from the cross-runs made connecting the longitudinal lines. For instance, if bench elevations are established along the lines *a b c d* and *a h g f e*, Fig. 1, independently of each other, it may happen that elevations will be assigned to *b* and *g*, *c* and *f*, or *d* and *e*, which will differ considerably from the cross-runs made connecting these points.

It became apparent that the adjustment should be made by using two longitudinal runs and two cross-runs, all four runs comprising one comprehensive closed circuit. The algebraic sum of the differences of elevation taken all around the circuit should equal zero. As generally happens, the algebraic sum, as obtained from the field notes, will differ from zero by a small amount, known as the error of closure for the circuit. This error should then be uniformly distributed along the entire circuit to make it a consistent whole. But even this modification did not remove all sources for embarrassing discrepancies. The circuit considered comprised within itself smaller circuits, or a side of this circuit was in common with a contiguous circuit. The circuit *a c f h* is made up of two smaller circuits; and also the side *c f* of this circuit belongs to the adjacent circuit *cd ef*. With the adjustment made on circuit *a c f h*, elevations will be obtained for *b* and *g*, which may differ considerably from the cross-run between these points. And should the circuit *c d e f c* be also adjusted, the elevations obtained for *c* and *f* from the first circuit adjustment may differ materially from what would be obtained for these points in this second circuit adjustment.

It would be possible by modifying some elevations as indicated by the discrepancies practically to eliminate most of the inconsistencies brought to light by this method of adjustment. But these modifications, as reasonable as they may be, do not obey any definite law. The problem arose to devise some logical method for the distribution of the errors of closure for a network of closed circuits, whereby the elevation of the benches, as determined by a rigorous procedure, would be consistent with one another. This problem can readily be solved by the application of the principle of least squares; and in what follows the derivation of the formulas giving the most probable distribution of the errors in elevation will be outlined.

Let circuits 1, 2 and 3, Fig. 1, be made counter-clock wise. Let E_1 be the albegraic sum of differences of elevation of circuit 1, E_2 that of circuit 2, and E_3 that of circuit 3. Further, let e_1 be the error in *g h a b* in the direction of the arrow, e_2 that in *b c*, e_3 that in *c d e f*, e_4 that in *f g*, e_5 that in *b g*, e_6 that in *c f*, and let L_1 be the length of *g h a b*, etc., etc.

The geometrical conditions which must be satisfied for the 3 circuits are:

$$E_1 + e_1 + e_5 = 0 \ldots\ldots\ldots\ldots (1)$$
$$E_2 + e_2 + e_6 + e_4 - e_5 = 0 \ldots\ldots\ldots\ldots (2)$$
$$E_3 + e_3 - e_6 = 0 \ldots\ldots\ldots\ldots (3)$$

Since the probable error in level work varies with the square root of the length of course, the errors, e_1, e_2, etc., have not the same weight, in general. Each one of the *e*'s must be divided by the square root of the length of course to which it has reference, to obtain errors of the same weight. Thus, $e_1/\sqrt{L_1}$, $e_2/\sqrt{L_2}$, etc., have the same weight. According to the theory of least squares, these errors will most probably be distributed so as to make the sum of the squares of the errors reduced to equivalent weights, a minimum. Therefore

$$e_1^2/L_1 + e_2^2/L_2 + \ldots\ldots + e_6^2/L_6 = \text{min.}$$

Differentiate

$$e_1/L_1 \, d\, e_1 + e_2/L_2 \, d\, e_2 + \ldots\ldots + e_6/L_6 \, d\, e_6 = 0 \quad (4)$$

Differentiate equation (1), (2) and (3)

$$d\, e_1 + d\, e_5 = 0 \ldots\ldots\ldots\ldots (5)$$
$$d\, e_2 + d\, e_6 + d\, e_4 - d\, e_5 = 0 \ldots\ldots\ldots\ldots (6)$$
$$d\, e_3 - d\, e_6 = 0 \ldots\ldots\ldots\ldots (7)$$

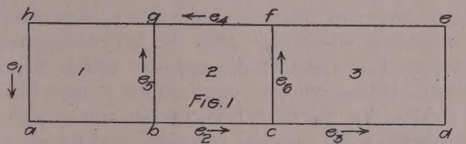


FIG. 1

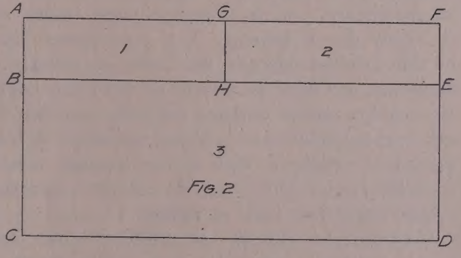


FIG. 2

Multiply equations (5), (6) and (7) by x_1, y_1 and z respectively, add them, and then subtract equation (4) there results

$$(x - e_1/L_1) \, d\, e_1 + (y - e_2/L_2) \, d\, e_2 + (z - e_3/L_3) \, d\, e_3 + (y - e_4/L_4) \, d\, e_4 + (x - y - e_5/L_5) \, d\, e_5 + (y - z - e_6/L_6) \, d\, e_6 = 0.$$

Let x, y and z be determined by placing the first three coefficients equal to zero. Then since the last three *e*'s are independent of each other, the coefficients of these must be equal to zero.

We have, therefore,

$$x - e_1/L_1 = 0 \ldots\ldots\ldots\ldots (a)$$
$$y - e_2/L_2 = 0 \ldots\ldots\ldots\ldots (b)$$
$$z - e_3/L_3 = 0 \ldots\ldots\ldots\ldots (c)$$
$$y - e_4/L_4 = 0 \ldots\ldots\ldots\ldots (d)$$
$$x - y - e_5/L_5 = 0 \ldots\ldots\ldots\ldots (e)$$
$$y - z - e_6/L_6 = 0 \ldots\ldots\ldots\ldots (f)$$

Multiply equations (*a*), (*b*), (*c*), etc., by L_1, L_2, L_3, etc., respectively. Thus reduced, add equations (*a*) and (*e*) and reduce by equation (1).

$$(L_1 + L_5) \, x - L_5 \, y + E_1 = 0 \ldots\ldots\ldots (A)$$

add equations (*b*), (*d*) and (*f*) and subtract equation (*e*) and reduce by equation (2)

$$- L_5 \, x + (L_2 + L_6 + L_4 + L_5) \, y - L_6 \, z + E_2 = 0 \ldots\ldots\ldots\ldots (B)$$

Subtract equation (*f*) from (*c*) and reduce by equation (3).

$$- L_6 \, y + (L_3 + L_6) \, z + E_3 = 0 \ldots\ldots\ldots (C)$$

Equations (A), (B) and (C) give values for x, y and z; and with these values e_1, e_2, e_3, etc., may be computed from equation (*a*), (*b*), (*c*), etc.

As a numerical illustration of the use of these equations in the adjustment of levels, assume $L_1 = 3$ miles, $L_2 = 1$ mile, $L_3 = 4$ miles, $L_4 = 1$ mile, $L_5 = 1$ mile, $L_6 = 1$ mile, $E_1 = + .031$ ft., $E_2 = - .027$ ft., $E_3 = - .040$ ft.

Substituting in equations (A), (B) and (C), there result $4\,x - y + .031 = 0$; $x + 4\,y - z + .027 = 0$, and $- y + 5\,z - .040 = 0$. From which $x = - .0058$, $y = + .0078$, and $z = + .0094$.

These substituted in equations (*a*) to (*f*) give $e_1 = - .017$, $e_2 = + .008$, $e_3 = + .038$, $e_4 = (+ .008) = + .007$, $e_5 = - .014$, $e_6 = - .002$.

Because the numerical work is carried out to but three decimal places, a very slight discrepancy will be obtained on trying to satisfy equation (2). But this discrepancy is removed by making $e_4 = + .007$.

Similar formulas may readily be obtained in the same manner for a more complicated system of circuits. In all cases, all the equations obtained will be simple and linear in form. Adjustment by the method of least squares may appear laborious, but as opposed to the other methods of adjustment, it possesses the great advantage of being direct. Moreover it does not result in embarrassing discrepancies, which the other imperfect methods invariably do; and in this respect it will prove time-saving.

To illustrate the ease with which a solution may be made for a different system of circuits than that used in the analysis, take the network of circuits in Fig. 2.

The actual errors of closure obtained for the circuits in Fig. 2 were $E_1 = + 0.016$, $E_2 = - 0.037$, and $E_3 = - 0.009$.

All these circuits were made counter-clock wise. The lengths of the stretches are $AG = GF = BH = HE = 2.4$; $AB = GH = FE = 0.8$; $BC = ED = 3.4$; and $CD = 4.8$, the unit of distance being 1,000 ft.

By studying equations A, B and C with reference to Fig. 1 and working by analogy, the following equations will be obtained for Fig. 2: $6.4\,x - 0.8\,y - 2.4\,z + .016 = 0$; $- 0.8\,x + 6.4\,y - 2.4\,z - .037 = 0$; and $- 2.4\,x - 2.4\,y + 16.4\,z - .009 = 0$.

From which $x = - .00127$, $y = + .00609$, and $z = + .00126$.

Probable error in $GAB = 3.2\,x = - .004$.

Probable error in $BCDE = 11.6\,z = + .015$.

Probable error in $EFG = 3.2\,y = + .019$.

Probable errer in $BH = 2.4\,(x - z) = - .006$.

Probable error in $HE = 2.4\,(y - z) = + .012$.

Probable error in $HG = 0.8\,(x - y) = - .006$.

By modifying the level work along the different stretches by the probable errors obtained, the closures of all the circuits will be made perfect.

HARBOR IMPROVEMENTS throughout the world have been investigated by Dr. E. L. Corthell, whose figures, obtained by correspondence with port authorities, show clearly that the steamships of the world are increasing in dimensions, particularly in draught, much more rapidly than the entrance channels to the ports are being deepened. At the time his data were obtained, 1904, there were 138 ports having a depth of less than 30 ft. at low water and 70 with 30 ft. or more. There were 95 ports having less than 30 ft. at high water and 113 having 30 ft. or more. When all channels are deepened as proposed, there will be 116 ports with less than 30 ft. at low water and 91 with 30 ft. or more; and there will be 71 with less than 30 ft. at high water and 136 with 30 ft. or more.

Chemical Engineering in the Packing House.

Some of the notable features of important new packing houses have been described in this journal during recent years, and these articles should convince the reader that the industry in its modern form is conducted with a high regard to both cleanliness and economy. The character of the buildings and power plants is already familiar through the articles previously published, but little has been said about the great strides that have followed the adoption of ideas suggested by the chemical engineer. The advent of this specialist occurred so recently, in fact, that few people recognize the importance of chemical engineering in the packing industry, and attention is therefore called to some interesting statements on the subject made in the "Rose Technic," by Mr. H. E. Wiedemann.

The modern packing house might properly be termed a "food factory," for in reality that is what it is. Animal and vegetable foods and compounds of the two are produced in many forms; together with these are also produced other edible compounds which closely verge on the pharmaceutical field. This is evidenced by the production of extract of beef, which could hardly be considered a food in the ordinary sense of the word. A step further, we have the preparations known as digestive ferments, which are not food, but still alimentary products. Still further bordering on to the pharmaceutical field are the preparations frequently produced in the larger plants, such as inspissated ox gall, etc., and the so-called animal extracts—cardine, testine, cerebrine, etc.

The most important feature in the utilization of by-products is observed in the fertilizer department, as here all animal products not useful for food or manufacturing purposes are converted into a highly remunerative article known as fertilizer, either complete fertilizer, or the crude form known as tankage, dried blood, hoof meal, bone meal, etc. The establishing of the fertilizer department may be said to mark the transition of the simple slaughter house of former days to the modern packing house in all its phases. With the knowledge gained from the utilization of one by-product, the utilization of the rest followed as a natural sequence.

The product of most importance in the fertilizer department is tankage, which is the name applied to the residue remaining in the tanks where meat, scrap, etc., is rendered to separate the fat. Practically all the meat that cannot be used for food is put into large tanks, approximately 6 x 16 ft., and cooked with steam under pressure for a number of hours. In charging the tanks, they are filled about half full with the material and then water is added until they are about two-thirds full. The tanks are then sealed and the steam turned into them. Each tank is fitted with a safety valve so in case the pressure rises beyond a certain point the excess can escape. After the material has been thoroughly cooked it is allowed to settle and the fat is withdrawn from an outlet near the top by forcing water into the lower part of the tank and raising the grease. When the water begins to show at the outlet pipe it is an indication that all the fat has been removed in that manner. The flow of water is now stopped, and the cooked, hot material, together with the water that remains in the tank is dropped into a box or vat underneath the tank. Here it is kept hot by steam pipes and whatever fat rises to the top is skimmed off. The latter is technically known as "skimmings." and is recooked with the next charge of fresh material.

The material in the vat is then allowed to drop onto press cloths and forms that are placed on the platform of the press immediately below the box. After building up ten or twelve layers they are placed in a press and pressure is applied for several hours, or until no more fat or water can be removed. The press cloths mentioned are large rectangular pieces of coarsely woven and very heavy cloth. In building up a press the cloth is spread over a square wooden form, about half the dimensions of the cloth, which has neither top nor bottom, and is about 6 in. high. The tankage is allowed to fall into this until the form is full. Then the cloth is folded over the top of each side and the form removed. A heavy flat framework of boards is placed over the cloth and the operation is repeated for the next layer. Hydraulic power is usually used for the pressure. The pressed tankage contains approximately 50 per cent. moisture after being removed from the press and shaken free from the cloths. The water and grease which have been pressed out of the hot tankage run to catch basins, where the fat, rising to the surface, is skimmed and recooked.

The pressed material is now transferred to the dryer for the final drying into a commercial product. There are a number of types of dryers on the market, both intermittent and continuous. The continuous dryers consist of three rotary cylinders about 20 ft. long and 3 ft. in diameter, built into a brick wall immediately over the furnace, which uses coal for fuel. The material is fed into the top at one end of the dryer by a continuous lift; it then slowly works its way to the other end of tube number one, and falls into the second tube. Then it moves back again to the end of the dryer from where it started and drops into the last tube, from which it emerges at the opposite end in a dry state, falling onto a reciprocating screen which divides the material into coarse and screened tankage. The material contains 10 per cent., or less, moisture, and is stored in large rooms until ready for shipment. The commercial value of this product depends upon the percentages of ammonia and bone phosphate as shown by analysis. A low grade tankage contains less than 10 per cent. ammonia and a high percentage of bone phosphate, while a high grade tankage always contains 10 per cent. or more ammonia and correspondingly less bone phosphate.

Concentrated tankage, or stick, as it is commonly called, is made by evaporating the tank water, which has been pumped into large vats after passing through the catch basins when leaving the tankage presses. In these large vats the water is kept just below the boiling point for several hours, and as any grease rises to the surface it is skimmed off. The water is now drawn into large vacuum evaporating pans where it is evaporated under reduced pressure until it has a very syrupy consistency (27° Beaume at 175° Fahr.). It is then pumped to another large vat where it is allowed to stand, at a moderate temperature, and from which it is pumped to the dryer as fast as it can be handled by the latter. At this stage, before entering the dryer, the material is mixed with some efflorescing material, usually copperas, for the stick, being very hygroscopic, would absorb moisture, if dried alone, so rapidly as to become sticky and lumpy, and consequently useless as fertilizer material. After drying, the product contains about 6 per cent. moisture and 12 to 13 per cent. ammonia. It is never sold to be used on soils directly, but is always used to mix with low grade tankage to increase the percentage of ammonia.

The bones from the different departments finally find their way to the bone room in the fertilizer department. Here they are cooked in boiling water in open vats and the grease and meat scraps which are cooked off are tanked and recooked. The bones are dried on shelves in rooms where the temperature is kept very high. After thoroughly drying they are assorted ready for market. The bones of the legs and feet yield "neats foot" oil when cooked, one of the most valuable animal oils manufactured. Some of the bones are ground and used for fertilizer, while a great many are worked up into fancy articles, such as knife handles, combs, buttons, etc. The hoofs from the slaughtered animals are cooked and dried, and when ground form a valuable material for mixing with tankage to increase the ammonia content. Hoof meal contains about 18 per cent. ammonia.

Another very important constituent of fertilizer is dried blood. The blood is conducted from the killing floors through sewers into large upright tanks, where it is boiled with open steam for about half an hour. This coagulates the albuminous matters and renders them practically insoluble. The clotted blood is then dropped into presses and pressed in a similar manner to tankage. The pressed blood contains about 50 per cent. moisture. It then goes to the dryer, from which it emerges as "dried blood," and falls onto a screen. The coarse particles that do not pass the screen are ground in a mill and mixed with the screened blood, after which it is ready for market. Clean ground blood should contain from 16 to 17 per cent. ammonia and from 5 to 6 per cent. moisture. The ammonia content depends largely upon the amount of refuse in the blood.

For mixing animal fertilizers to make complete fertilizers ready for the soil, it is necessary to add to the bone, tankage, etc., other materials as diluents, and also some form of potash. The latter is commonly commercial potassium chloride and at times potassium sulphate. The diluents, or fillers, may be any cheap material, such as finely ground ashes or earth. If the fertilizer should be used on soil without any dilution it would be too strong for the plants.

Probably the next by-product in importance is glue. It is now made in the packing houses from raw material that used to be sold to glue manufacturers, and from liquors that were formerly wasted. The chief sources of glue are the water or liquors from the boiling of the heads, feet and bones of the slaughtered animals; and from sinews, hide trimmings, horn piths, etc. In the manufacture of glue it is of great importance that the material shall be in prime condition when used. If allowed to lie around in heaps or subjected to incipient decomposition it will very quickly become unfit for use as glue; or if used will produce only a low grade, foul-smelling product. One of the chief products of the glue department is bone glue, which is prepared by cooking the bones in boiling water in open vats, and evaporating the resultant liquors to the required density in the vacuum pans. By using vacuum evaporators the pressure can be diminished, thus allowing a lower temperature for evaporation, and lessening the danger of scorching the product. Sometimes the bones are leached with acid to dissolve the inorganic matter in them. For this purpose they should be tough and hard, and as free as possible from grease. They are covered with dilute hydrochloric acid from three to four weeks, depending upon the size of the bones. After this leaching the bones are soft and spongy, and have a rather strong odor. They are then drained free of acid and washed with clean water until all trace of the acid is removed. The resultant product is known as "raw gelatine" and furnishes glue and gelatine upon cooking. The best grades of edible gelatine are usually made from horn piths in the manner just described.

The glue liquors are frequently bleached in order to give the finished product a lighter color. One of the common methods is to pass sulphur dioxide through them until the desired light color is obtained. In addition to bleaching the glue the gas also acts as a preservative. It is very necessary that some sort of preservative be used to keep the liquors from decomposing, and aside from sulphur dioxide, zinc oxide is most commonly used for this purpose, also having the power of producing a light-colored glue. Formaldehyde has of recent years been used to some extent, but if an excess is used, the glue will be rendered insoluble almost immediately. From the evaporating pans the liquor is pumped into molds in the chill rooms and allowed to chill, after which it is cut into layers about an inch thick and placed on trays in the drying ovens. After coming from the oven, or drying room, the glue is ready for the market.

Another use to which the blood from the slaughtered animals is put, besides the manufacture of dried blood, is the manufacture of blood albumen. The blood as it comes from the animals is caught in large shallow pans and allowed to rest without stirring or agitation until it clots; if the blood at this time is stirred or agitated it will be defibrinated and the proper separation cannot be made. After clotting it is cut into small pieces and placed in shallow pans with perforated bottoms, through which the serum or albumen drains from the clot. The serum at this stage of the process is of a pinkish or light red color, due to the presence of red corpuscles that were not separated by clotting. These red corpuscles have to be separated—and in order to carry out this process the serum is placed in a shallow pan in the bottom of which is a perforated rubber stopper through which a small glass or lead tube extends until it reaches just above where the surface of the liquid will be when the pan is filled. The pan is then filled with the serum and allowed to stand for a few hours in a cool place, during which time the red corpuscles begin to sink. As the liquid clears at the top and the red corpuscles sink lower and lower the tube is gradually lowered and the clear supernatant serum is drawn off into suitable vessels placed underneath. It is then placed in small enameled plates, which have previously been slightly greased, and kept at a temperature of about 110° Fahr. until dried; after which it is scraped off the plates and is ready for market. Blood albumen finds a very extensive use in the textile industries in the printing of cotton fabrics.

Another by-product which is used extensively in medicine is pepsin. This is prepared from the mucous membrane of the stomachs of hogs, although it may be made from the stomachs of other animals. The stomachs are emptied of their contents and thoroughly cleansed in cold water. Then the outsides of the stomachs are trimmed away and the membranous portion is chopped into small pieces and placed in water acidulated with 3 or 4 per cent. of pure hydrochloric acid. It is allowed to remain in this solution, kept at a temperature of 104°-120° Fahr., until it undergoes self-digestion, so to speak. This operation is materially assisted by frequent stirring, but it requires from 36 to 48 hours, and sometimes longer, for the solution to be effected. At this stage the liquid is very prone to decomposition, especially in the presence of ozone, as occasioned by thunder storms, and great watchfulness is required. If sulphur dioxide be passed through the liquid until it smells strongly of the gas, an antiseptic condition is occasioned and also a bleaching of the product. In this condition the solution is allowed to stand and clarify itself by the precipitation of the mucous. The clear liquid is then decanted, and common salt is added to it, the temperature being maintained at about 95° Fahr. until complete separation of the pepsin results by precipitation. The pepsin thus obtained, the floating scum, when collected, pressed and dried, constitutes crude pepsin, which even in this form is marketable, being very active and meeting certain requirements of trade. It has a faint but not disagreeable odor, a brownish yellow color and a slightly salty taste. In the purification, the crude pepsin is dissolved in weak hydrochloric acid and the solution thus obtained subjected to dialysis by any suitable means until the salt has been eliminated. The purified liquor is then concentrated, usually in a vacuum pan, with the temperature not above 105° Fahr. The concentrated solution is then dried as rapidly as possible on glass plates, the edges of which are raised to hold the liquid. When dry the pepsin is scraped from the plates, and is known as scale pepsin, the pure pepsin of commerce.

Beef peptone is made by digesting beef by means of the pancreas of the beef. The tougher and leaner the meat the better will be the yield of peptone. In the preparation the beef is very finely minced, and to twenty-five parts of this are added eight parts of the pancreas and four of water. The mixture is allowed to digest in a jacketed kettle, at a temperature not exceeding 130° Fahr., for six hours, after which time the solids will all have passed into solution through a true digestive process. During this time the mixture must be frequently stirred to facilitate the action. The solution is filtered through canton flannel bags and bleached by passing sulphur dioxide through. The bleached solution is then evaporated to dryness on a water bath.

Pancreatin is a digestive ferment existing in the pancreas, or sweetbreads, of animals. It is made from the pancreas of the hog in a way similar to that of pepsin from the hog's stomach.

Another interesting class of pharmaceutical products, animal extracts, are made from the various organs of the slaughtered animals, and are said to be very beneficial in the treatment of diseases of the organs in man similar to those from which the various extracts are made. These extracts were first prepared by Dr. Hammond, of this country. Among the extracts are: Cardine, from the heart of the bullock; medulline, from the spinal cord of the bullock; testine, from the testes of the bull and ram; ovarine, from the ovaries of the hog; musculine, from the muscular tissues of the bullock; thyroidine, from the thyroid glands of the sheep and the bullock, and cerebrin, from the brain of the bullock. In the preparation of these extracts the organ before being used has to be carefully examined in order to insure freedom from affection in any form. It is then thoroughly washed in water acidulated with boric acid and then cut into small pieces in a mincing machine. About one kilogram of this substance is placed in a flask, together with one litre each of a saturated solution of borax in distilled water, pure glycerine and absolute alcohol. This mixture is allowed to stand for at least six months, being well shaken several times a day. At the end of this time it is placed upon a stone filter and allowed to percolate through, which requires about two weeks. The residue remaining upon the filter is inclosed in aseptic gauze and subjected to a very high pressure, the exudate being allowed to fall upon the filter and mixed with a sufficient quantity of the filtrate to cover it. When this has entirely filtered it is thoroughly mixed with the first filtrate, and the process is complete.

The chemist plays an important part in the manufacture of all these products. He has to analyze all the tankage for moisture, ammonia, bone phosphate and fat; the blood for moisture and ammonia; the complete fertilizer for moisture, ammonia, bone phosphate and potash; the tallows, oils, lard, etc., for free fatty acids, hardness, flowing point, impurities, etc.; besides a great number of miscellaneous tests. He is also called upon to analyze the raw material that is bought for use in the plant, such as vinegar, sugar, salt, lubricating oils, cotton seed oil, etc.

Book Notes.

The extent to which concrete is used in houses of various sizes is well shown in a large album of fine engravings, entitled "Concrete Country Residences." It contains illustrations of structures having reinforced concrete frames, with terra-cotta filling and stucco finish, others of concrete throughout, others of brick and concrete, and others of stucco on wire lath. These range in size from small buildings costing only a few thousand dollars up to imposing examples of palatial homes. The pictures are all taken from the finished buildings, not from the perspective drawings of the architects, and are accompanied by floor plans, so that the volume is not only interesting as a record of what has been done with concrete in this line, but also as a collection of drawings showing the interior arrangements of recent work by our leading architects. (New York: Atlas Cement Co., $1.00.)

There are many engineers who will be gratified to know that Mr. H. H. Suplee has edited a collection of "Five Figure Logarithms," which has been published in a thin, morocco-covered volume, very handy for the pocket or the desk. These tables give the logarithms of numbers and angular functions, the hyperbolic logarithms of numbers from 1 to 134, the logarithms of important numbers, and an excellent explanation of the uses of book. One of the drawbacks to employing such tables for computations requiring greater accuracy than that of the ordinary slide rule has been the necessity of using large books in consulting the tables, for even the ordinary "pocket-book" must be considered pretty bulky when employed for the purpose. It is of course impracticable to say whether any errors have crept into the tables, but the name of the editor is a guarantee that great care has been taken to secure accuracy. (Philadelphia: J. B. Lippincott Co., $2.00.)

One of the most complete investigations undertaken by a single individual of the conditions of the buildings in San Francisco after the earthquake and fire of last spring was that made by Mr. A. L. A. Himmelwright, M. Am. Soc. C. E., the inventor of the Roebling system of fireproof construction. In the course of three weeks spent in the city, he examined every building of a fireproof character there. Levels were taken, the condition of the frame, walls and partitions was investigated, and admirable photographs were specially taken under his direction. The results of his studies have been issued in a large volume, profusely illustrated, entitled "The San Francisco Earthquake and Fire." It is a book hardly practicable to review in detail, but it is one every architectural engineer will find of unusual interest. The lessons of the fire, in the author's opinion, are the following: (1) Protect the openings of the outside walls against the "exterior fire hazard"; (2) protect the columns and other important structural members in proportion to the requirements; (3) use refractory materials for the façades; (4) select a concrete floor construction of recognized strength and fire resistance; (5) adopt reinforced concrete for partitions; (6) never permit pipes inside the column protection; (7) provide metal treads for the stairways; (8) provide for the expansion of metal lintels and mullions; (9) the filling between the fireproof floor arches and the under side of the finished floor should never be omitted; (10) avoid light support and copper wire in metal lath and plaster ceiling construction; (11) the small steel vaults and portable fireproof safes, even of standard makes, proved most ineffective in preserving their contents. The lessons drawn from the earthquake by Mr. Himmelwright are as follows: (1) Avoid locations in close proximity to geologi resented,
n electro-

(2) the foundation must be capable of moving as a unit; (3) adopt the steel skeleton frame method for the superstructure; (4) the best materials and workmanship only are admissible for wall construction; (5) avoid high chimneys and towers of plain masonry; (6) roofing tiles should be thoroughly anchored in position. (New York: Roebling Construction Co.)

The name of M. Feret, director of the Laboratory of the Bureau of Bridges and Highways of France at Boulogne, is so well known to American engineers through his valuable papers on the properties of cement and concrete, that his new book, "Etude Expérimentale du Ciment Armé," is certain of a warm welcome on this side of the Atlantic. It has for its basis a series of experiments which are carefully explained in the first part of the volume. These tests have been conducted during a long period of years, with both small and large beams, and with loads gradually applied as well as with those of an alternating character. The second part is devoted to theory and methods of calculation. It is intended particularly to show the difficulty of the subject from the point of view of pure theory, owing to the multiplicity of the factors to be considered. While the author concedes that some of these factors are not of importance in practical design, he nevertheless insists that the user of a simplified formula should understand the complete theory, so as to appreciate the degree of approximation involved in his working methods. The author does not advance any new working formulas, not only because of the abundance of those already in existence, but also because an official French commission of concrete specialists has just reviewed the subject. In his discussion of this portion of his field, general formulas are first taken up, and then the phenomena of rupture in isotropic non-ductile materials, rupture by bending in a homogeneous prism, and rupture in reinforced concrete beams are explained. The simplification of formulas by making various assumptions is then discussed, and a number of methods of making graphical calculations are explained. Finally there is an instructive chapter on the elements which complicate computations and introduce errors. The third part of the book is a bibliography of reinforced concrete, which will prove of special value to those who have access to files of foreign journals. The fourth and concluding part gives a collection of experimental data relative to the strength and other properties of the materials entering into reinforced concrete, with full discussions of the methods of making the tests and the deductions to be drawn from them. The book as a whole cannot be reviewed properly in any detail except by devoting many pages of this journal to such a notice, so it must suffice to say that those engineers who read French and are interested in reinforced concrete will find the volume of the highest value. (Paris: Gauthier-Vallars, 55 Quai des Grands-Augustins; paper, large 8vo, 20 francs.)

Letters to the Editor.

Good Building Contract Forms.

Sir:—Your leading editorial in The Engineering Record for Oct. 20 strikes the nail square on the head. Your words "the continual evolution of efficiency needs the spur of self-interest" are Baconian in their pregnancy and truth. The absence of the "spur of self-interest" in building in the great cities of this country, especially in New York, is responsible for many and great abuses. High wages, small output, uncertainty as to cost and time of completion of buildings, these are some of them.

[illegible]ct that a shrewd general contractor or contracting architect, to use a phrase which is beginning to find considerable vogue, can, by dividing up the work so as to fit the caliber of small sub or piece-meal contractors, "trade the boots off" the said gentlemen is the argument to-day for the percentage system of building. Notwithstanding employers' associations, which, by the way, are doing a good work in preventing or trying to prevent too low prices, the sharp-trading gentry above referred to are generally able to "land" a bunch of small contractors at prices which are so low as to impel them to skin or "extrafy" the work out of all semblance to what was specified originally, the skinning changing the essence of the work on the one hand or the "extrafication" changing the cost on the other.

Time was when the percentage plan was a saving to the owner in cost, the sure profit to the contractor being considered as an offset to the larger gain that might be made and generally was made. Nowadays the true argument in favor of percentage work is superior quality and the removal of temptation to get the work done too cheaply, which in turn caused "skinning." But this percentage plan has produced an unexpected result, for under it the owners are skinned instead of the work. Of course, the owners don't know it. When they have finished and paid up they are often terribly disappointed, sometimes crippled and in instances bankrupted, but they are lulled into peace of mind by the statement that labor is so uncertain and difficult to manage, etc., etc.

Now, the fact is that sub or piece-meal contractors are not in the favored percentage or cost-plus-a-fixed-sum class. Their work is always for a price. Sometimes it is their own prices, but oftenest it is a price fixed in competition, and the argument about quality being dear and only obtainable on percentage or cost-plus-a-fixed-sum does not apply to them. What a Garden of Eden we would live in if all the work down the line were percentage or cost-plus-a-fixed-sum work. Talk about taking candy from babies! No, the sub or piecemeal contractor has no such luck. His work is all for a price, as I said before, and he is looking for the percentage general contractor with a lasso, for it is from him that he expects to get the plums which will fill the gaps in his (the sub's) pocketbook—gaps made by the shrewd-trading general contractor or contracting architect.

The percentage contractor is the only "easy fruit" left in the building business. He has no interest in the thing except to "get a good job," forsooth. How can he consistently resist the arguments of the sub-contractor that good things come high, for has he not used the same argument on the owner who is paying the freight?

But the moral responsibility, you will say—that will restrain the percentage contractor. Not for long. The game is too hard. Put not thy faith in moral responsibility, Mr. Owner, in these strenuous days. Quick time is the ambition and the pride of every builder. When he can't make quick time, the builder decries it. He talks about shoddy work and "heavy repair charges," but if he ever gets a chance to do a quick stunt, especially at an owner's expense, see how he swells out his chest! Hear him boast!

Do not trust too much to the sense of moral responsibility when it comes to leading a charge of sub-contractors bound for a record. Somebody will get lost in the shuffle and it won't be the percentage or cost-plus-a-fixed-sum contractor, of course, and the chances are very strong that it won't be the sub-contractor, either. Besides, it is too easy to work the old time-honored excuse that the labor situation is such that, etc., etc., ad nauseam.

What the building business needs is responsibility, responsibility of the builder for his work exactly as the locomotive builder or ship builder is responsible, responsibility, too, in the other sense of being strong enough to be responsible for his work when it is finished. And with this responsibility goes a pride in the work which will not allow it to be slighted.

Owing to the fact that contracting architects are able to get a collection of bids from irresponsible subs which total up anywhere from 5 to 20 per cent. less than the price at which any responsible contractor will offer to do the work, responsible builders are often shown up at a disadvantage, but the bad results of the contracting architect plan of working, in poor work, extras, delays, lawsuits, have made the percentage contractor's opportunity, but, as I have shown, he is too often used by the sub-contracting fraternity to make good the losses incurred in the general run of their work due to excessive competition, which no power or influence seems able to curb.

The cure for the trouble is found in a middle ground between the two extremes. A good builder should be chosen if you would have good work. He should be willing to guarantee that the work as specified shall not exceed a certain figure, and then to protect the owner against overcharge he should agree to reduce the guaranteed price by as much as he may save after charging a certain profit for himself. And then if you go a little further and give the builder a percentage of the saving—without freeing him from responsibility for the proper character of the completed structure—you have an ideal arrangement, one which is legitimate in every sense and which makes of the building business an institution in which there is some real human incentive to the "continual evolution of efficiency."

New York, Oct. 23. Theodore Starrett.

Tests of Clay Pipes.

Sir: At the time of publication, Aug. 18, 1906, I overlooked the article on the testing of clay and concrete pipes by Mr. H. Burchartz. Even at this late date you may be interested in knowing that series of tests were made in this country in 1890 by methods quite similar to those given in the above mentioned article. I am sending you in another cover "Some Experiments to Determine the Strength of American Vitrified Sewer Pipe."

Yours truly, Malverd A. Howe.

Terre Haute, Oct. 12.

[The paper referred to in this letter was published in the "Journal" of the Association of Engineering Societies, in 1891, and in it Prof. Howe gives the result of tests of 15 samples of sewer pipe. The experiments included hydrostatic, drop, concentrated load, uniform load and cement joint tests, and the paper gives complete descriptions of the methods employed and results obtained. Prof. Howe drew the following conclusions from the tests:

1. From the results obtained it seems safe to conclude that the average ultimate tensile strength of the material composing American vitrified sewer pipe is at least 600 lb. per square inch.

2. That the average pipe will safely stand any ordinary shock or blow.

3. That the average pipe will support 2,000 lb. at its center when supported at points 16 in. apart.

4. That the average pipe will support 2,000 lb. per linear foot when bedded in sand.

5. That cement joints made with the ordinary well and spigot are not safe when subjected to pressure, unless the pipe is prevented from moving longitudinally.

6. That ring joints are but little stronger than the ordinary bell and spigot joints when the pipe is unconfined.]